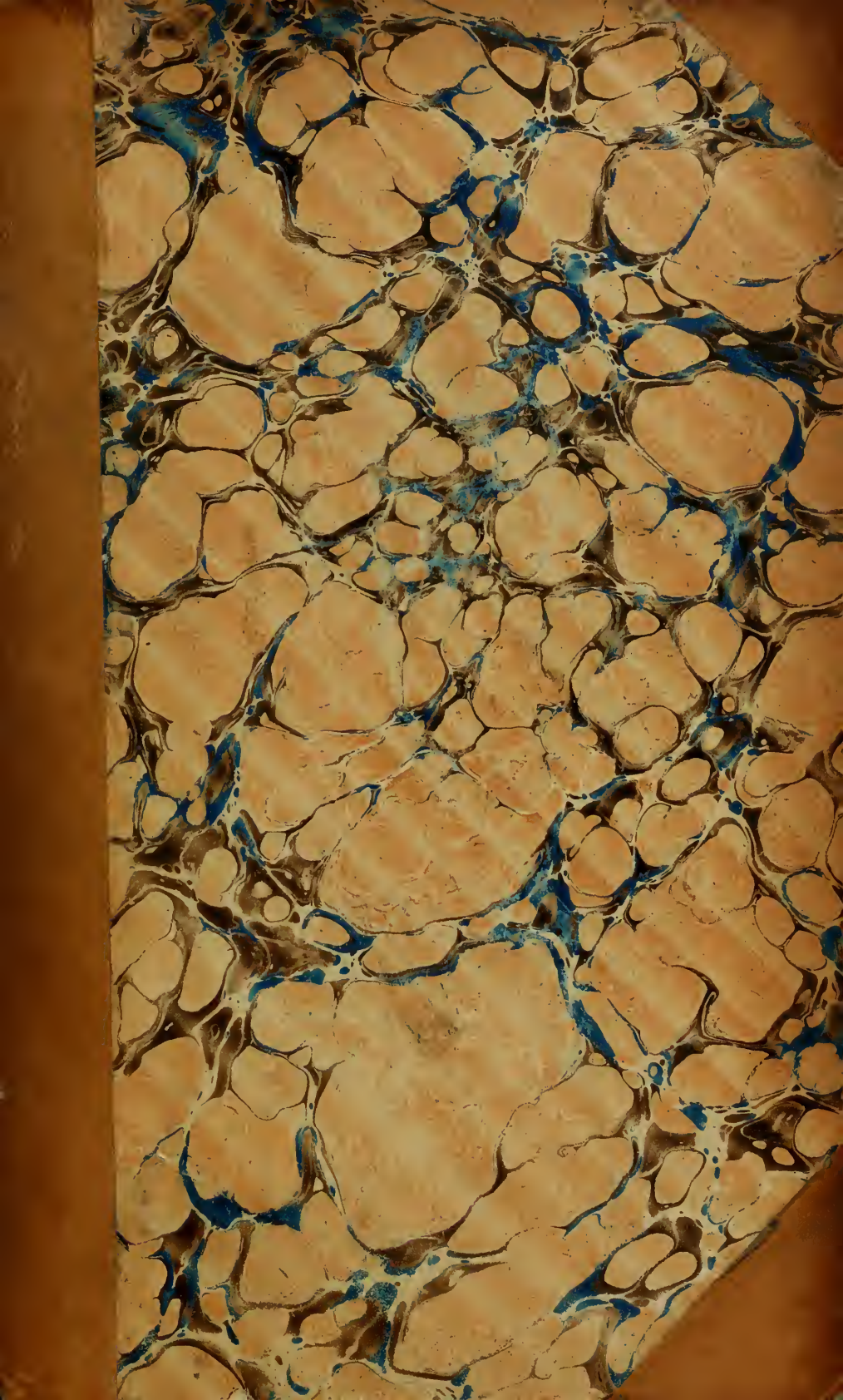




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JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

DEVOTED TO

MECHANICAL AND PHYSICAL SCIENCE,

Civil Engineering, the Arts and Manufactures.

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JOURNAL
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PROMOTION OF THE MECHANIC ARTS.

JANUARY, 1866.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

On the Construction of the Screw Propeller of Uniformly Expanding Pitch. By D. M. GREENE, U. S. Naval Engineers.

In projecting the working plans of the screw propeller of uniformly expanding pitch, the practice of draftsmen is not only variable, but signally defective in system, and in many cases totally wanting in accuracy. In many instances, screws constructed from drawings intended to represent screws with uniformly expanding pitches, are neither what they were designed to be, true screws, or, indeed, screws of any description whatever. They may with propriety be called *propellers*, but never screws.

The best method now practiced in "laying down" the screw, is, in our opinion, that which regards the subject as simply a problem in descriptive geometry; and determines all the elements, except those expressing the conditions of the question, by a system of projections. This method, however, is tedious; and the results, notwithstanding the greatest care may be observed in the construction, are vitiated by errors which unavoidably creep in and accumulate as the work progresses. Nor is this all; the sections of the screw blade determined by this method, are not real sections, but are merely projections of the curves of the blade upon planes, with the actual thicknesses of the blade laid off upon these projections; thus making sections which are neither the actual sections of the blade or projections of them.

How, then, can the pattern-maker and moulder be expected to furnish us with perfect screws?

We are of those who believe that, if there is any merit in the screw of uniformly expanding pitch, advantage can be taken of it only by making it so. With this view, we have constructed a formula for calculating the ordinates of the curve of the guide-plate used in sweeping up the mould, and have adopted a new method of constructing the sections of the blades.

To construct the formula, suppose the guide-plate constructed; and let ABC , Fig. 1, (Plate I,) represent its development (exaggerated of course) upon a plane parallel to the axis of the screw. AC will be the portion of the circumference occupied by one blade, and BC will be the length of the screw, or the terminal ordinate of the developed helix AB .

Divide AC into n equal parts; erect ordinates to the curve at each point of division, and conceive tangent lines drawn to the curve at the points where these ordinates meet it. The angles which these tangent lines make with AC , at their respective points of tangency, will be the angles of the screw at those points.

Let θ = angle of the screw at posterior edge A .

θ' = " " " anterior " B .

φ = pitch " " posterior "

φ' = " " " anterior "

x = each of the equal divisions of $AC = \frac{AC}{n}$.

y_1, y_2, y_3 , &c. = ordinates to the points a, b, c , &c., of the developed helix.

R = radius of the screw.

c = circumference of the screw.

k = decimal, expressing the part of the circumference occupied by one blade.

Before proceeding further, however, let us examine the nature of the curve AB for a moment. If Δ represent the slight decrease in pitch between A and a , (of course the pitch *decreases* from the after to the forward side,) there will be a like decrease of pitch between a and b , b and c , and so on to B ; hence if

$$\begin{aligned}\varphi &= \text{pitch at } A, \\ \varphi - \Delta &= \text{" " } a; \\ \varphi - 2\Delta &= \text{" " } b;\end{aligned}$$

$$\text{and } \varphi - n\Delta = \varphi' = \text{" " } B.$$

Now it will be remembered by those familiar with the screw, that the tangent of the angle of a screw is equal to the pitch divided by the circumference. We shall, therefore, have for the tangents of the angles of the screw at the successive points of the developed helix—representing these angles by $\theta, \theta_1, \theta_2, \dots, \theta_n = \theta'$ —

$$\tan \theta = \frac{\varphi}{2\pi R} = \frac{\varphi}{c}.$$

$$\tan \theta_1 = \frac{\varphi - \Delta}{c}.$$

$$\tan \theta_2 = \frac{\varphi - 2\Delta}{c}.$$

$$\tan \theta_3 = \frac{\varphi - 3\Delta}{c}.$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$\tan \theta_n = \tan \theta' = \frac{\varphi - n\Delta}{c} = \frac{\varphi'}{c}.$$

Subtracting,

$$\tan \theta - \tan \theta_1 = \frac{\varphi}{c} - \frac{\varphi - \Delta}{c} = \frac{\Delta}{c}.$$

$$\tan \theta_1 - \tan \theta_2 = \frac{\varphi - \Delta}{c} - \frac{\varphi - 2\Delta}{c} = \frac{\Delta}{c}.$$

$$\tan \theta_2 - \tan \theta_3 = \frac{\varphi - 2\Delta}{c} - \frac{\varphi - 3\Delta}{c} = \frac{\Delta}{c},$$

&c.; hence, we see that the tangents of the angles of the screw diminish by a constant difference; *i.e.*, uniformly from the after to the forward edge of the blade; or *increase* by a constant difference from the forward to the after part.

Having established this point, we are prepared to proceed with the construction of the formula. Putting the constant difference found

above, $\frac{\Delta}{c} = \delta$. We have also,

$$\begin{aligned} \delta &= \frac{\tan \theta - \tan \theta'}{n} \\ &= \frac{\frac{\varphi}{c} - \frac{\varphi'}{c}}{n} \\ &= \frac{\varphi - \varphi'}{cn}, \end{aligned} \quad \cdot \quad \cdot \quad \cdot \quad (1.)$$

Now,

$$y_1 = x \tan \alpha_1.$$

But,

$$\alpha_1 = \theta - f \Lambda a,$$

and since $f \Lambda a$ is the angle included between the tangent to the curve at Λ and the chord Λa , the difference—in this particular case—between the tangent of θ and the tangent of α_1 , due to $f \Lambda a$, will be equal to *half* the common difference of the tangents of the angles which the consecutive chords make with Λc ; and, consequently, equal to half the common difference of the tangents of the angles which the consecutive *tangent lines* make with the Λc . This common difference being

δ , we shall evidently have $\tan \alpha_1 = \tan \theta - \frac{\delta}{2}$,

$$\therefore y_1 = x \left(\tan \theta - \frac{\delta}{2} \right). \quad \cdot \quad \cdot \quad \cdot \quad (2.)$$

But,

$$x = \frac{A C}{n} = \frac{K c}{n},$$

which, being substituted in (2), together with the values of θ and δ already found, gives

$$\begin{aligned} y_1 &= \frac{K c}{n} \left(\frac{\varphi}{c} - \frac{\frac{1}{2}\varphi - \frac{1}{2}\varphi'}{c n} \right) \\ &= \frac{K c}{n} \left(\frac{\varphi n - \frac{1}{2}\varphi + \frac{1}{2}\varphi'}{c n} \right) ; \\ &= \frac{K}{n^2} \left[\varphi(n - \frac{1}{2}) + \frac{1}{2}\varphi' \right]. \quad . \quad . \quad (3.) \end{aligned}$$

Again,

$$y_2 = y_1 + x \tan \alpha_2.$$

But,

$$\alpha_2 = \alpha_1 - d a b,$$

and $d a b$, being the angle between the two consecutive chords $A a$ and $a b$, and equal to the angle between two consecutive tangents, the difference between the tangents of α_1 and α_2 will evidently be δ . So, also, will the differences between $\tan \alpha_2$ and $\tan \alpha_3$, $\tan \alpha_3$ and $\tan \alpha_4$, &c., each be equal to δ ; hence, the preceding value of y_2 becomes

$$\begin{aligned} y_2 &= y_1 + x (\tan \alpha_1 - \delta) \\ &= y_1 + x (\tan \theta - \frac{3}{2}\delta). \end{aligned}$$

Substituting, as before, the values of x , $\tan \theta$, and δ , and also placing for y_1 its value from (3), we have

$$\begin{aligned} y_2 &= \frac{K}{n^2} \left[\varphi(n - \frac{1}{2}) + \frac{1}{2}\varphi' \right] + \frac{K c}{n} \left(\frac{\varphi}{c} - \frac{\frac{3}{2}\varphi - \frac{3}{2}\varphi'}{n c} \right) \\ &= \frac{K}{n^2} \left[\varphi(n - \frac{1}{2}) + \frac{1}{2}\varphi' \right] + \frac{K}{n^2} \left[\varphi(n - \frac{3}{2}) + \frac{3}{2}\varphi' \right] \\ &= \frac{K}{n^2} \left[\varphi(2n - \frac{4}{2}) + \frac{4}{2}\varphi' \right], \quad . \quad . \quad (4.) \end{aligned}$$

In an entirely similar manner, and for the same reasons, we obtain

$$y_3 = y_2 + x (\tan \theta - \frac{5}{2}\delta).$$

Substituting values, this becomes

$$\begin{aligned} y_3 &= \frac{K}{n^2} \left[\varphi(2n - \frac{4}{2}) + \frac{4}{2}\varphi' \right] + \frac{K c}{n} \left(\frac{\varphi}{c} - \frac{\frac{5}{2}\varphi - \frac{5}{2}\varphi'}{c n} \right) \\ &= \frac{K}{n^2} \left[\varphi(2n - \frac{4}{2}) + \frac{4}{2}\varphi' \right] + \frac{K}{n^2} \left[\varphi(n - \frac{5}{2}) + \frac{5}{2}\varphi' \right] \\ &= \frac{K}{n^2} \left[\varphi(3n - \frac{9}{2}) + \frac{9}{2}\varphi' \right], \quad . \quad . \quad (5.) \end{aligned}$$

Similarly,

$$y_4 = \frac{K}{n^2} \left[\varphi(4n - \frac{16}{2}) + \frac{16}{2}\varphi' \right], \quad . \quad . \quad (6.)$$

$$y_5 = \frac{K}{n^2} \left[\varphi(5n - \frac{25}{2}) + \frac{25}{2}\varphi' \right], \quad . \quad . \quad (7.)$$

&c. Examining, now, the values of y_1 , y_2 , y_3 , &c., we observe that

the co-efficient of n , in the parenthesis, is in each case equal to the number of the ordinate from the beginning of the curve; also, that the numerators of the fractions are equal to each other, and equal to the *square* of the number of the ordinate. We are, therefore, enabled to write, at once, the general formula for the value of the m th ordinate, thus;

$$y_m = \frac{K}{n^2} \left[\varphi(mn - \frac{m^2}{2}) + \frac{m^2 \varphi'}{2} \right], \quad . \quad . \quad (8.)$$

If, now, we make $m = n$, (8) becomes

$$\begin{aligned} y_n &= \frac{K}{n^2} \left[\varphi(n^2 - \frac{n^2}{2}) + \frac{n^2 \varphi'}{2} \right] \\ &= \frac{K}{n^2} \left(\frac{\varphi + \varphi'}{2} \right) \\ &= K \left(\frac{\varphi + \varphi'}{2} \right) = l, \quad . \quad . \quad . \quad (9.) \end{aligned}$$

If, again, we make $K = 1$, or, if we extend the blade entirely round the axis, (9) becomes

$$y_n = \left(\frac{\varphi + \varphi'}{2} \right) = \text{mean pitch},$$

which proves the correctness of our formulæ.

It will be observed that the ordinates computed by the aid of the general formula (8) are each entirely independent of all the others, and, consequently, not affected by accumulative numerical errors, or by errors of construction. Each ordinate thus computed, can be laid down as accurately as it is possible to lay down any computed distance.

In the case of a screw having a uniformly varying pitch from hub to periphery—if such a screw, or *propeller*, were desirable—our formula is equally applicable, it being only necessary to construct guide curves at equal intervals from hub to periphery, or simply *two* curves, one at the hub and the other at the periphery. We should have remarked before, that the ordinates calculated for the periphery of a screw of uniformly varying pitch, “fore and aft,” answer equally as well for all the sections between the periphery and hub, as for the curve the curve of the guide-plate.

EXAMPLE.—Let $\varphi = 24$ feet, $\varphi' = 20$ feet, $K = .16$, and $n = 10$. Then will

1st dif. 2d dif.

$$\begin{aligned} y_1 &= \frac{.16}{100} \left[24 \left(10 - \frac{1}{2} \right) + \frac{20}{2} \right] &= .3808 \quad .3808 \\ y_2 &= \frac{.16}{100} \left[24 \left(2 \times 10 - \frac{4}{2} \right) + \frac{4}{2} \times 20 \right] &= .7552 \quad .3744 \quad .0064 \\ y_3 &= \frac{.16}{100} \left[24 \left(3 \times 10 - \frac{9}{2} \right) + \frac{9}{2} \times 20 \right] &= 1.1232 \quad .3680 \quad .0064 \\ y_4 &= \frac{.16}{100} \left[24 \left(4 \times 10 - \frac{16}{2} \right) + \frac{16}{2} \times 20 \right] &= 1.4848 \quad .4616 \quad .0064 \end{aligned}$$

$$y_5 = \frac{\cdot 16}{100} \left[24 \left(5 \times 10 - \frac{25}{2} \right) + \frac{25}{2} \times 20 \right] = 1 \cdot 8400 \quad \cdot 3552 \quad \cdot 0064$$

$$y_6 = \frac{\cdot 16}{100} \left[24 \left(6 \times 10 - \frac{36}{2} \right) + \frac{36}{2} \times 20 \right] = 2 \cdot 1888 \quad \cdot 3468 \quad \cdot 0064$$

$$y_7 = \frac{\cdot 16}{100} \left[24 \left(7 \times 10 - \frac{49}{2} \right) + \frac{49}{2} \times 20 \right] = 2 \cdot 5312 \quad \cdot 3424 \quad \cdot 0064$$

$$y_8 = \frac{\cdot 16}{100} \left[24 \left(8 \times 10 - \frac{64}{2} \right) + \frac{64}{2} \times 20 \right] = 2 \cdot 8672 \quad \cdot 3360 \quad \cdot 0064$$

$$y_9 = \frac{\cdot 16}{100} \left[24 \left(9 \times 10 - \frac{81}{2} \right) + \frac{81}{2} \times 20 \right] = 3 \cdot 1968 \quad \cdot 3296 \quad \cdot 0064$$

$$y_{10} = \frac{\cdot 16}{100} \left[24 \left(10 \times 10 - \frac{100}{2} \right) + \frac{100}{2} \times 20 \right] = 3 \cdot 5200 \quad \cdot 3232 \quad \cdot 0064$$

In the value of y_{10} , if we put unity for $\cdot 16$, the value of y_{10} becomes $22 \text{ feet} = \frac{24 + 20}{2} = \text{mean pitch}$. It will be observed, also, that the second differences are constant, both of which facts prove the accuracy of our results.

We now proceed to illustrate our method of constructing the working drawing of the screw given in the preceding example, so far as it is essentially different from the methods we have seen employed.

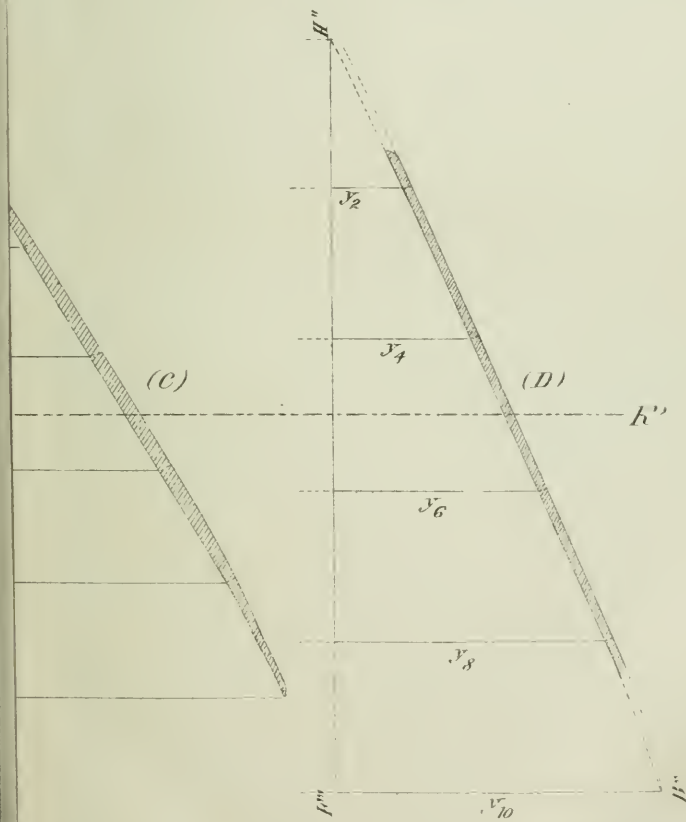
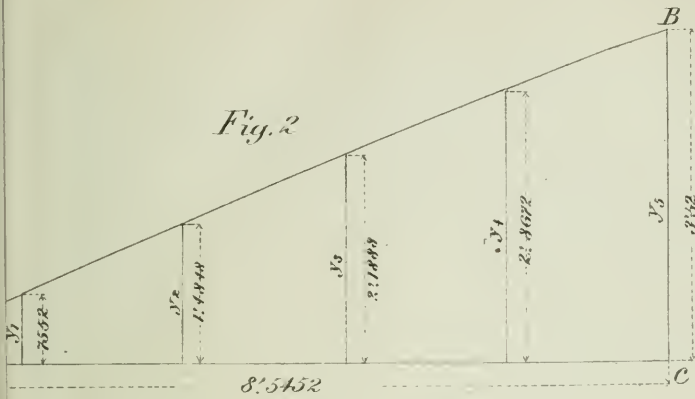
Let $R = 8$ feet; Draw $\kappa \kappa'$, Fig. 3, (Plate I,) as the centre line of the blade and its sections; take any point E as a centre, and with a radius equal to the radius of the screw, describe an indefinite arc. Calculate $\cdot 16$ of $360^\circ = 57^\circ 48'$, and lay off half of this angle on each side of $\kappa \kappa'$; the sector EFH thus determined, will represent the projection of one blade on a plane perpendicular to the axis. Next, divide the radius into any number of equal parts, say four, and through the points of division draw the arcs ab , cd , and ef , concentric with FH ; also, draw an arc, Ac , 6 inches outside the periphery to represent the position of the *guide-plate*.

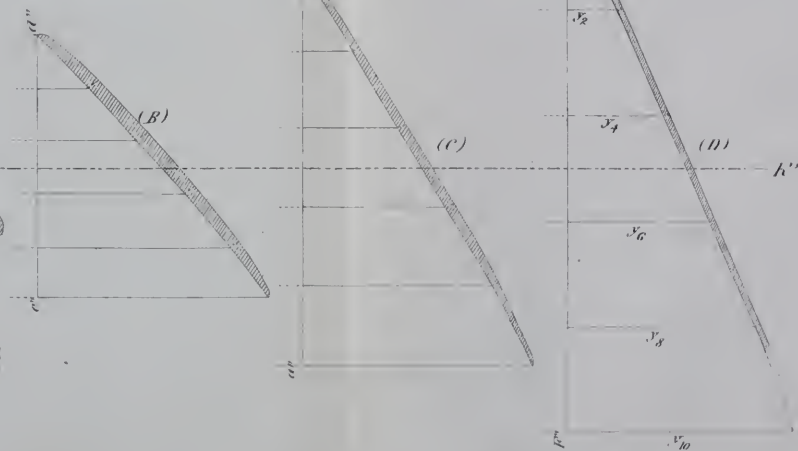
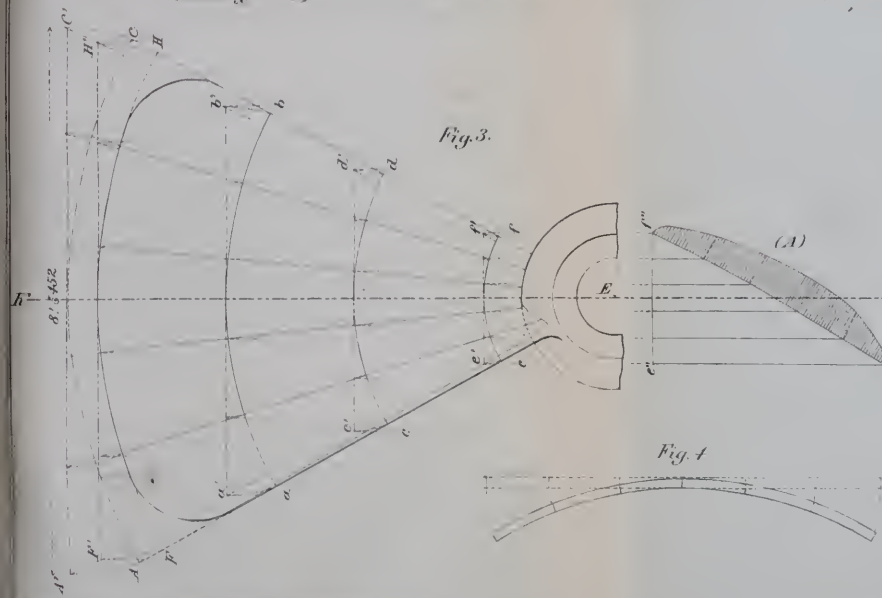
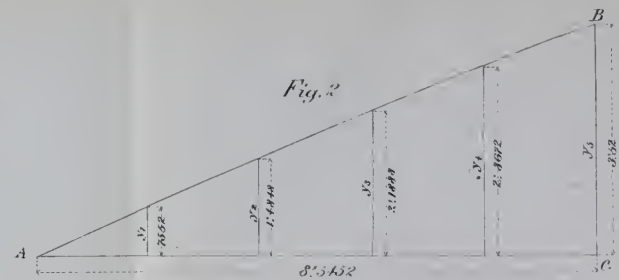
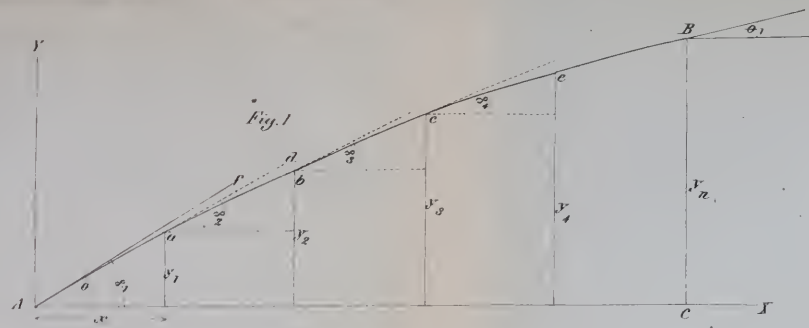
Now, divide the arc Ac into any convenient number of equal parts, generally ten; but in this case we only use five. Through the points of division draw radii dividing the projection of the blade into five equal sectors. Next calculate the circumference for the radius $AE = 8 \cdot 6''$, and find $\cdot 16$ of that circumference, which will be $8 \cdot 5452$. Draw $A'c'$ tangent to Ac at its middle point; make it equal to $8 \cdot 5452$ feet; divide it into five equal parts, and draw lines from $A'c'$ and the points of division, to the centre E ; also, draw tangents to the middle points of each of the arcs FH , ab , cd , and ef .

Then will $A'c'$, $F'h'$, $a'b'$, $c'd'$, $e'f'$ be the developments of the corresponding arcs, upon the tangents drawn to their middle points, and, consequently, perpendicular to $\kappa \kappa'$. The intersections of these tangents by the lines drawn from $A'c'$ to the centre, will evidently be equidistant, and represent the positions of the points of division of the arcs, in their respective developments.

Next, upon the opposite side of E , at equal intervals, each slightly greater than the length of the screw, (or the greatest computed ordi-

Fig. 2





nate,) draw as many perpendiculars to $\kappa \kappa'$, as there are arcs upon the blades. Then project the extremities and points of division of $F' H'$, in lines parallel to $\kappa \kappa'$, upon the most remote of the perpendiculars last drawn; and in like manner project $a' b'$, $c' d'$, and $e' f'$ upon corresponding perpendiculars; $F' H'$ will then be found in $F'' H''$, $a' b'$ in $a'' b''$, $c' d'$ in $c'' d''$, and $e' f'$ in $e'' f''$.

Finally, lay off at the points of division of $F'' H''$ the ordinates y_2 , y_4 , y_6 , y_8 , y_{10} , already computed, and draw a curve through their extremities; in like manner lay off these same ordinates at the points of division of $a'' b''$, $c'' d''$, and $e'' f''$, and draw curves through their extremities.

The curves thus constructed will represent the exact lengths (not projections as is usually the case) of the parallel helices of the blade, of which the arcs $F H$, $a b$, $c d$, and $e f$ are the projections. Laying off upon these curves the proper thicknesses of the blade, and drawing another set of curves through their extremities, we have the sections (A), (B), (C), and (D) of the blade represented in their actual dimensions; from which the measurements for the "thickness strips" can be directly taken.

Fig. 4, (Plate I,) represents a "thickness strip," made in a single straight piece; then cut away, by sawing, at small intervals, so that it may be easily bent to fit the circular arc of the blade.

To construct the drawing for the guide-plate, Fig. 2, (Plate I,) we have only to lay off $\Lambda C = 8.5452$ feet, divide it into five equal parts, erect perpendiculars, lay off the computed ordinates at the points of division, and draw a curve through their extremities.

We have, in this example, used only *five* ordinates, that number being sufficient for our purpose of illustration. In a working drawing, however, it is of course better to use ten.

Figs. 2 and 3, (Plate I,) comprise all that is necessary in a working drawing of a screw propeller of uniformly expanding pitch; excepting, only, the length of the hub, which we have not represented, and the *sweep*, which, in the case of a blade curving backward, would require a representation either of the sweep or of its curvature.

Washington, D. C., November 15, 1865.

Ventilation of Sewers. By JAMES LEMON, A.I.C.E.

From the Civil Engineer and Architect's Journal, November, 1865.

The ventilation of sewers is one of those subjects upon which a great many suggestions have been made, but still very few of them have been carried out. The system adopted in the Metropolis (excepting in the main drainage) is exceedingly primitive: it consists, as many persons well know, of a vertical shaft about 3 ft. square in the clear, built upon the top of the sewer, and covered at the top by means of two gratings about 2 ft. by 6 ins. each, flush with the surface of the road. The results of this arrangement are: the smell from the sewage is allowed to pass up into the streets at a level where it is most objec-

tionable and the foul gases are inhaled by the persons passing; likewise, the gratings become choked with the mud and stones from the roads, or the bottom of the sewer becomes full of deposit washed or swept down the ventilators. In the main drainage system there is a cesspit about 2 ft. 6 ins. square by 6 ft. in depth under the ventilating gratings which receives the detritus from the roads. This cesspit is connected with a vertical shaft adjoining thereto, built over the sewer in the same manner as the ordinary ventilating shafts. In the wall between the cesspit and the shaft there are two openings, one next the bottom fitted with a small iron grating to allow the water to drain off and to prevent the passage of stones, &c., into the sewer; the other for ventilation, which is intended to be fitted with trays containing charcoal, so that the foul gases may be disinfected. In this method, however, the choking of the gratings is not remedied, therefore it cannot be considered one that can be recommended for general adoption.

The sewers of Paris are ventilated by means of iron pipes, which are connected with the branch sewers or house drains, and are carried up either in the thickness of the front walls of the houses, or outside the walls to the top of the roof. This plan, in some instances, has been objected to; but if the joints were screwed and securely fitted, the inlet connected with a charcoal filter in the sewer, and the outlet carried up above the roof of the house or adjoining building, there can be no reason why it should not be the best mode of ventilation that has yet been devised. One of the chief causes of complaint in Paris is the imperfect way in which the gullies or inlets for the street drainage are constructed; they are in some cases trapped, but the trapping is certainly not efficient, as the smell therefrom in some of the best parts of the city is very offensive.

Amongst the many modes of ventilation which have been proposed, there is one which might be easily adopted in the manufacturing districts, and that is to utilize, with consent of the owners, the tall chimneys, by connecting them with the ventilating shafts of the sewers; this would promote a current of air through the sewers, and draw off the noxious gases. Ventilation of sewers might also be effected by carrying up an iron tube in the centre of the lamp standards at the crossings of the main streets, similar to those in Southwark street, London, the inlet being connected with a charcoal filter in the shaft from the sewer. This mode could not, from the isolated position of the outlet, be a nuisance to the occupiers of the houses in the locality, and would be an improvement on the present ventilators in the centre of the streets, flush with the surface of the roadway. Advantage might also be taken of the end walls at the corners of streets for carrying up ventilating tubes to the tops of the houses, as in Paris, so as to remove the objection to ventilation. A very curious mode of ventilation was suggested by Admiral Sir E. Belcher, which may be thus described: the foul air was to be taken from the sewers by means of a pipe connected therewith, and carried up to the top of the lamp-posts, and there discharged. This rather novel way of mast-heading the stink, although it may be very nautical, might be objected to by per-

sons occupying the first floors of houses opposite the outlet; in fact, the gallant admiral himself would find it somewhat unpleasant if he happened to be sitting at an open window to the leeward.

Side Entrances.—The side entrances to sewers should not be made, as a rule, more than 1000 feet apart; they bear a small proportion to the whole cost, and they are exceedingly convenient for repairs, making connexions to house drains, cleansing, &c.; they should in every case be provided with a ventilator and cesspit, so that foul gases may not collect in the entrance shaft. The most convenient place for placing a side entrance is at the corner of a cross street, so that it may be available for access to the junction of the sewers at that point. Side entrances are usually constructed with an entrance shaft from 2 ft. 6 ins. to 3 ft. square in the clear, with a horizontal gallery or chamber to the sewer about 6 ft. 6 ins. in height by the width of the shaft. A very useful size for the entrance shaft is 3 ft. by 2 ft. 6 ins. Iron ladders, for access thereto, are much preferable to foot irons, and are now being adopted in most modern works constructed by well known drainage authorities. The entrance covers should be made as light as possible consistent with strength, and should be provided with wrought iron gratings so constructed that both could be easily opened by one man from the *inside*. The cast iron covers and gratings used under the Metropolitan Commissioners of Sewers are excessively heavy and clumsy, weighing between 4 and 5 cwt., so that if a workman should happen to be in the sewer and the flap become accidentally closed, he would be completely trapped, and must wait until he receives assistance from above.

Side entrances might be more extensively used with advantage in pipe drainage, or, as they might be more strictly termed, shafts, for the purpose of inspection, flushing, &c. These shafts could be sunk below the level of the bottom of the pipe sewer, so as to form cesspits; on the lower side of the shafts nearest the outlet penstocks could be fixed, so that a head of water could be raised at each shaft, and the pipe sewer flushed as far as the next shaft, into the cesspit, at which point, when sufficient head was obtained, the penstock could be raised, the next length flushed, and so on to the outlet.

Junctions.—The junction of branch sewers with the main sewer should be made on a regular curved line, with a radius not less than 30 ft. The level of the invert of the branch sewer should be above that of the main sewer, such difference of level should be equal to the difference of height of their respective inverts, or in other words, the arches should spring from the same level. It is recommended by Mr. Rawlinson that the fall of curved junctions should be increased, to compensate for friction; where sufficient fall can be obtained such increased gradient will no doubt be advantageous. Bell-mouthed junctions should be provided with ventilators and cesspits, to allow the foul gases to pass off at the highest point where they mostly accumulate.

House Drains.—House drains should in every case be formed of glazed stoneware pipes; they should be well laid to a regular gradient on a sound foundation of the maiden ground, or of concrete, so

that no settlement might take place, and thereby cause deposit, and ultimately stoppage. Drainage should not be taken through the houses under the floors if it can by any means be avoided. Water closets should be placed next external walls, so that they may be drained as direct as possible. Sinks should be connected with the drain of the water-closets, so as to flush it with the house washings, also the overflow from the waste of the cisterns.

A six-inch glazed drain pipe, with a proper fall, will be sufficient for the entire drainage of an eight-roomed house, and four-inch pipes for the sink and rain-water. Drain pipes should be connected with the sewer on a curved line, and the drain mouths should be provided with galvanized iron shackle-flaps, to prevent smell or flood waters from rising up the house drains. All drains should be trapped by means of a syphon bend, or other suitable arrangement, at a point easy of access in case of stoppage; also, all inlets for surface drainage of yards, areas, &c., should have cesspits, with syphon overflows, as one of the surest means of preventing deposit in drains is to check the admission of sand and other matter at these points.

Resistance of Water to Floating and Immersed Bodies.

From the London Mechanics' Magazine, September, 1865.

Prof. Rankine read an interim report of the Committee appointed for experimenting on the difference between the resistance of water to floating and immersed bodies. The experiments not being complete, the committee deferred a detailed report. The committee had several meetings during last winter and spring, and agreed to a programme of experiments. Two models of ship-shape, four feet long and painted, were made and employed in those experiments. The experiments were made according to the method formerly put in practice by Mr. Scott Russell, in which the uniformity of the propelling force was maintained by means of a regulating weight hanging from a pulley, under which the hauling cord passes, the model being guided in a straight course by means of a stretched wire. The experiments were made with the models both totally immersed and only half immersed. The execution of the experiments was superintended by Mr. Scott Russell, as being the only member of the committee resident in or near London. The actual performance of the experiments was entrusted by Mr. Russell to Mr. J. Quant, who had performed the duty with great skill and assiduity. A lake in Blackheath Park was kindly granted for the experiments by Dr. Joseph Kidd. Twenty-eight experiments had been made on the first model, with the following results: 1. The resistance, when immersed so as to be just covered with water and no more, was more than double its resistance when half immersed, at the same speed. 2. When the after body of the model was turned so as to convert the water-line into buttock-line, its resistance was increased, and that whether the model was half immersed or just covered. The report deferred the detailing the description of the experiments until they should be completed.

For the Journal of the Franklin Institute.

Leveling and Surveying by Means of a Visual Angle and Rod.

By S. W. ROBINSON, C. E.

In the February number of this *Journal*, for 1865, will be found a paper written upon this subject.

My chief object was there to give a rigorous analysis of the problem of leveling, and of measuring distances by means of a visual angle and rod, and to derive therefrom formulæ, accurate and also approximate, suitable for practical use. I considered the question with reference to holding the rod normal, or perpendicular, to the central visual ray, and to the horizon; and also adapted the analysis to an unequal division of the visual angle, allowing the middle thread of the reticule of the telescope to be that centered upon the target when measuring the vertical angle,—the target being attached to the rod, or painted upon the stadia. I also considered in the analysis the correction due to a change of the focus of the telescope for the stadia at small and greater distances, and gave the maximum amount of error which would follow from neglecting it entirely.

In the January number of the same volume of the *Journal*, there appeared a valuable article upon a similar subject, by Mr. J. R. Mayer, C. E. His formulæ agree exactly with the approximate formulæ which I gave, though neither had any knowledge of the doings of the other in the matter, until the results appeared in the *Journal*. He did not give the amount of, nor even mention the fact that the adjustment of the focus of the telescope for a satisfactory reading of the stadia at small and great distances is a source of error unaccounted for in the formulæ. I found, however, that the maximum error from this cause never exceeds about one and a half times the focal length of the object-glass in the horizontal measure, and the same multiplied by the sine of the vertical angle in vertical measure.

This error, it is plain, arises from a change in the magnitude of the visual angle, on account of adjusting the reticule—which should be constantly in the focus of the eye-glass for the same eye—to a proper distance from the object-glass for viewing the stadia in various positions. And it is also plain that for the stadia at the same distance from the object-glass, the reticule must always be brought to the same distance from it also. This will follow whether the eye of the observer be short or long sighted, because the focal length of the object-glass is entirely independent of it. Thus, if a screen be placed behind a convex lens or an object-glass, and the image of any object brought out distinctly upon it, and, if for the screen a reticule of wires be substituted, then the reticule will be in the focus of the glass. And now if the reticule be viewed by an eye-glass, both the image and reticule will appear together. Now, if the reticule and image be viewed by a different eye of different focus, it is only necessary to extend or retract the *eye-glass** slightly, when they will both appear to the new ob-

* Not the eye-piece, unless regarded as distinct from the slide carrying the reticule. In the inverting telescope where the Ramsden's eye-piece is used, the slide-tube usually carries both the eye-glass, or eye-piece and the reticule, which are kept at the same constant distance from each other, except when adjusting for the focus of the eye.

server as perfectly as they did to the other, without having changed the relative positions of the reticule and object-glass. All this is true of the telescope of the stadia instrument.

From this fact it is plain that *the only necessary change to adapt any stadia instrument to the use of any observer, is simply a proper adjustment of the eye-glass upon the reticule in the beginning.* He will then obtain the same position of the reticule with respect to the object-glass for distances of one, five, or more hundred feet. Consequently, a stadia properly made for any particular object-glass or telescope, will never need any alteration whatever for different observers. These principles, as well as being in keeping with the principles of optics, I have entirely corroborated by actual experiment with a good stadia instrument.

Mr. Mayer states that the vertex of the visual angle is at the eye of the observer. Although this is sufficient for the approximate formulæ which he gives, yet strictly it is at the *object-glass* at an infinite number of points, but may be regarded as at its optical centre. The two planes of rays which proceed from the spider threads of the reticule, and intersect at the optical centre of the object-glass, exactly contain the visual angle on either side of the glass. Knowing this fact, and the focal length of the glass, it is easy to calculate the interval between the wires of the reticule for any given case, which is equal to the focal length multiplied by the tangent of the given visual angle.

In my previous article upon the stadia, I stated that in order to find the length of the divisions of the stadia, it was desirable to use a base of about 1000 feet, assuming 1500 as the maximum reading to be made in practice. But when it is the intention to use the approximate formulæ, the work will be more nearly correct by selecting a base line, the length of which shall be near a mean of the readings that may be taken in the field work. Since the reading of distances less than this base will be too small, and of distances greater than the base too large, it is probable that the plus and minus errors will nearly balance in long courses. But when it is designed to use the accurate formulæ of (21) and (22) of my article in the number referred to, the base may be taken at pleasure.

Methods for determining the heights and horizontal distances graphically from the field notes have already been explained. This diminishes greatly the time and trouble otherwise required without much injury to the accuracy of the work, if the diagrams are properly constructed.

The diagrams illustrated by Mr. Mayer for reduction to the horizon are very good, although I would suggest the use of vertical lines drawn to the horizontal scale, and both this and the vertical scale numbered with the proper numbers, divided by 10, 100, 1000, &c., if necessary; then the diagram will give directly the required quantity, without the use of a pair of dividers and a scale.

The quadrants which were described, answer a good purpose for getting the heights, but these require a pair of dividers and a scale. The plan of using triangles does not necessitate the use of any other

instrument. They were designed by myself for this purpose. Noting in the mind a reading of stadia, and the corresponding vertical angle, the height is at once traced out upon the triangle and given in the required numerical quantity. In my previous paper upon the stadia, in giving directions for the construction of these triangles, I made an error in stating that the lines drawn from the horizontal scale should intersect at the opposite angle of the triangle. They should be drawn parallel to each other. Specific directions for the construction of the triangles are given below.

Heretofore we have only considered the question of graphical computation as regarding the reduction of observations by these approximate formulas, viz :

$$x = R \cos^2 v, \text{ or } R - x = R \sin^2 v, \text{ and } y = \frac{1}{2} R \sin 2v.$$

But I now propose to show how diagrams can be obtained for graphical determination of the heights and distances in strict accordance with the accurate formulas (21) and (22) given in the February number. These diagrams once constructed, the labor required in their use is the same as that for diagrams made to the approximate formulæ, except adding a small quantity, nearly constant, depending upon $(c + f)$ attached to the diagram, a sacrifice which is small compared with the satisfaction of having the work reduced by correct principles. The correct formulæ (21) and (22) are

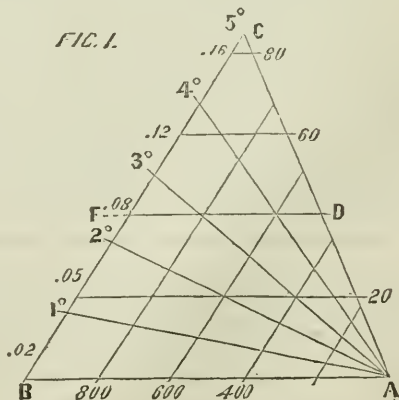
$$x = R \cos^2 v \left(1 - \frac{c+f}{x^1} \right) + (c+f) \cos v, \quad (21)$$

$$y = \frac{1}{2} R \sin 2v \left(1 - \frac{c+f}{x^1} \right) + (c+f) \sin v, \quad (22)$$

in which x is the horizontal distance required, y the required height, R the reading of the stadia, v the vertical angle, f the principal focal length of the object-glass, c the distance of the Y's from the object-glass, and x^1 the base line used in getting the dimensions of the stadia divisions.

These formulæ are correct for a stadia uniformly divided, unless the two parts of the visual angle, formed by the three spider threads of the reticule of the telescope are *very* unequal.

Now, let us suppose for a moment, the diagram scale ABC, Fig. 1, to be so constructed that the vertical scale, AC, gives the horizontal distances $= x = R \cos^2 v$, which corresponds with the approximate formula. This quantity may be computed and the number put in its proper place as at D in the vertical scale, which will be the required horizontal distance for all intersections on the line DF.



We notice that the first part of the second member of (21) is $R \cos^2 v$ $\left(1 - \frac{c+f}{x^1}\right)$, which is the same as the approximate formula excepting the parenthetical quantity, which is always a constant fraction for the same stadia and instrument. Consequently, instead of $R \cos^2 v$ we should have a certain fractional part of it ($\frac{99}{100}$ for example) for every intersection on the line D F. Hence, if we put at D, $\frac{99}{100}$ of the quantity we had computed, we will have a diagram giving the correct amount corresponding to $R \cos^2 v \left(1 - \frac{c+f}{x^1}\right)$ instead of $R \cos^2 v$.

What is true of one line, D F, of the vertical scale is true of all. The diagram thus far completed gives the first and most important part of the second member of (21). The second part, $(c+f) \cos v$, is small and varies but slightly for a change of a whole degree in v . Consequently, values of this may be calculated and put on the diagram, or in a table at one side of it. All that has been said of (21) is also true of (22).

Let us calculate some of the quantities and construct the skeleton of a diagram which shall give some of the values of y required by (22) to the first five degrees. Let us take $x^1 = 1000$; and as R may be any quantity let it be taken at 1000. Let $f = 1.3$ and $c = 0.7$. Then for $v = 5^\circ$, $\frac{R}{2} \sin 2v \left(1 - \frac{c+f}{x^1}\right) = 500 \sin 10^\circ \left(1 - \frac{2.0}{1000}\right) = 86.6 +$.

Similarly if

$v = 1^\circ$	$\frac{1}{2} R \sin 2v \left(1 - \frac{c+f}{x^1}\right)$	$= 17.4$	and	$(c+f) \sin v = .03^{.02}$
$v = 2^\circ$	"	"	34.8	" " 0.7 ^{.05}
$v = 3^\circ$	"	"	52.2	" " .10 ^{.08}
$v = 4^\circ$	"	"	69.5	" " .14 ^{.12}
$v = 5^\circ$	"	"	86.6	" " .17 ^{.16}

Now, draw A B and A C, Fig. 1, and take A B a scale of 1000 equal parts. Make a scale of equal parts on A C, and designate the tens by the proper numbers, and draw lines parallel to A B: and as we have designed to make 5° the upper limit, take the point c at 86.6 of the vertical scale, and draw B C. Then on B C at a point which shall correspond with 69.5 of the vertical scale, draw a line to A. This will be the line of 4° . Thus proceed until all the lines designating degrees are drawn. Draw lines parallel to B C from equidistant points of the horizontal scale A B. The quantities depending on $(c+f)$ may be placed in the diagram as represented. The diagram is now complete except that subdivisions may be made to any extent desired.

To use this diagram, find on the scale, A B, the number equal the reading of the stadia; then follow the line till it intersects with that drawn from A, expressing the number of degrees of the vertical angle. Note the position of this point in the vertical scale. Its height after adding $(c+f) \sin v$ is the height required.

If one triangle will not contain a sufficient number of degrees, 25 for example, of the vertical angle without confusion of lines, the num-

ber of triangles can be increased. But in any triangle which does not begin with zero degrees, the lines of the vertical scale, A C, will not be parallel to A B. To show this more clearly, let us construct a diagram commencing with 10° and ending with 14° . Then for

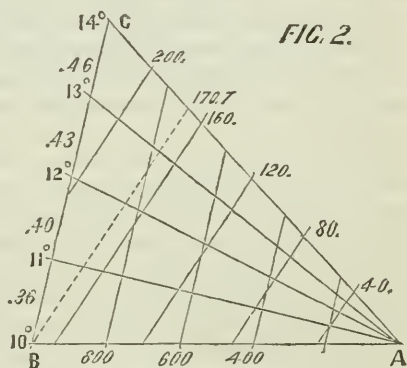
$$v = 10^\circ \frac{1}{2} R \sin 2v \left(1 - \frac{c+f}{x^1} \right) = 170.7, \text{ and } (c+f) \sin v = .35$$

$v = 10^\circ$	"	"	186.9	"	"	.38
$v = 11^\circ$	"	"	205.0	"	"	.42
$v = 12^\circ$	"	"	218.8	"	"	.45
$v = 13^\circ$	"	"	231.2	"	"	.48
$v = 14^\circ$	"	"		"	"	

Now, draw A B and A C, Fig. 2, and construct a scale of equal parts on each as before, A C containing 234.2 equal parts. Since the diagram must give 170.7 for $R = 1000$ and $v = 10^\circ$, we will draw a line through B and 170.7 of the scale A C, parallel to which draw all the other lines of this scale. Then from the point of intersection of B C with a line through 186.9 of the vertical scale, draw a line to A. This is the line of 11° . Thus proceed to obtain the lines for 12° , 13° , &c. The quantities $(c+f) \sin v$ may be treated as before. I have only computed the quantities for the even degrees. Quantities for subdividing to any extent desired may be calculated in a similar manner. The lines I have supposed drawn from A C to B C for designating points on B C are only temporary or imaginary. It is better to draw permanent lines only at regular intervals which can be numbered with integral numbers.

Diagrams for (21) can be constructed by following a course entirely similar to that pursued for (22).

These diagrams when once constructed for any particular instrument, can only be used with strict propriety for this or other instruments having the same distance intervening between the Y's and the object-glass, of which also the principal focal length is the same, or in which $(c+f)$ is the same, since this in the formulæ may be regarded as a single quantity. The errors in the use of these diagrams, however, will always prove to be less than if obtained from diagrams answering to the approximate formulæ $R \cos^2 v$ and $\frac{R}{2} \sin 2v$, except where $(c+f)$ for the instrument used is less than about half the value given it in making the diagrams. From this, in connexion with the fact that $(c+f)$ in all the ordinary stadia instruments used will never differ one-half, it appears that these diagrams are preferable to those adapted to the approximate formulæ.



Diagrams answering to the approximate formulæ, can be constructed in a form similar to that for (21) and (22).

To give good results the triangles should have eight or ten inches on a side.

The accuracy of the work which can be performed by the use of the stadia instrument is surprising. A fair trial is sufficient to remove all prejudice, if any exists. If it does exist, it must be in the idea of getting distances by sight. But if we inquire into the facts of the case, we find this to be a species of triangulation, the stadia being the base of a triangle in which all the angles are known. The visual angle being very much magnified, the power of measuring distances by it is magnified also. The only fear of great and unaccountable errors entering into the work must be chiefly from an apprehension of changes in the visual angle. Experience, however, shows that if the reticule be properly constructed, it cannot undergo appreciable changes. The redetermination of the delicate intervals of the reticules of astronomical transits proves their practical permanency.

For all the formulæ and diagrams considered in this article, the stadia should be held in a vertical position while taking observations upon it.

Some of the many advantages in the use of this instrument are that the data will always give both the heights and horizontal distances; and the vertical distance, easily gained by a single setting, will exceed ten times the rise possible to obtain by a leveling instrument at a single setting. In meandering rivers, lakes, &c., labor is saved of cutting lines for the chain; and it matters not so much what irregularities of surface are encountered.

The stadia and instrument are a substitute for the transit, the level, and the chain, and fewer assistants and men are required to accomplish the same amount of work, and, instead of its being in the hands of two or three, it may all be subject to the control of one observer.

It will be found to be a most economical and expeditious method of running preliminary lines for railroads, canals, laying water pipes, and for making topography, to which it is peculiarly adapted. It has advantages for locating points of interest in mining regions where there has been no land survey, and for furnishing data for geological maps and charts.

MECHANICS, PHYSICS, AND CHEMISTRY.

Incrustation of Steam Boilers.

From the London Mechanics' Magazine, March, 1865.

We have recently noticed corrosion as one of the ills to which the boiler is heir, and we will now consider another of a less insidious but not less dangerous nature, viz: incrustation. This evil is too frequently regarded merely as a matter of inconvenience, or, at the most, as a nuisance of which the owners of boilers would be very glad to be

relieved. But this is a false light in which to view it, for it is a source of positive danger, and not unfrequently the cause of steam boiler explosions. Witness the facts of a recent colliery boiler explosion. Here was a plain cylindrical egg-end boiler, 40 ft. long by 5 ft. 3 ins. diameter, made of $\frac{3}{8}$ ths in. plates, and working at a pressure of 30 lbs. per square inch. It was fitted with two sufficient safety valves and two floats, one of them having a lower water alarm whistle. The plates over the furnace became overheated, and the boiler was rent in four pieces. There was no evidence of a deficiency of water, but the cause of the overheating was attributable simply to the sedimentary character of the water. The number of boilers which suffer from incrustation is very large; indeed, to find one that does not is quite exceptional. It impedes the satisfactory examination of a boiler, inasmuch as it renders it difficult to ascertain the precise condition of the plates. It sometimes deludes by awakening groundless suspicions of corrosion; more frequently, however, it conceals defects, for it is often found that corrosion is stealthily going on under the deposit which is causing it. A great waste of fuel is one of the evils resulting from incrustation; in addition to this, and apart from overheating, there must be a considerable increase in the wear and tear of boilers. In internally double-flued boilers, the undue longitudinal expansion given to the furnace crowns increases the tendency to groove at the front end plate. In these boilers this action is always present to a greater or less extent. In localities where good water is not to be had, incrustation renders the adoption of tubular boilers impracticable, thus excluding this economical class of boiler from more general use. But the injurious effects of water which will cause incrustation are not always limited to the boiler. The steam carries over a considerable quantity of earthy matter into the engines, and so necessitates an increased amount of grease for the piston and slides. As an illustration of this fact it may be noticed that, where the feed water of boilers is taken from brooks subject to torrents which stir up the mud, the engine-men find the pistons and slides clog if they neglect the precautionary measure of extra lubrication.

The causes of incrustation do not lie very deeply hidden; it is, therefore, but a simple matter to determine them, existing as they do in the water with which the boiler is supplied. Carbonate and sulphate of lime form the principal constituents of water. The carbonate in precipitating forms a loose powder, but the sulphate a hard crust. Both together will also form a solid incrustation more or less hard in proportion as the one or the other of the salts predominates. This deposit, when allowed to accumulate, forms a hard scale which adheres very tenaciously to the iron, and is troublesome to remove. There is, no doubt, much difficulty experienced by the owners of boilers in judging of the quality of the water they have to use, but it is always open to them to have a chemical analysis made; and this is often essential when there are two or more sources of supply in the same locality, as the water, although apparently obtained from the same primary source, may differ very greatly in its composition at two different points. There

is an instance of this in a well which produced almost pure water containing an alkali but no lime. From this well a boiler was supplied for many years without any incrustation having been formed, the boiler being cleaned by simply brushing out. Within half a mile of this well another was sunk, but which yielded water containing so large a proportion of lime that in a few weeks a thick incrustation was formed within the boiler fed with it. Both wells were sunk through London clay into the chalk. It is a fallacy to attempt to estimate water from its appearance; transparency does not always mean purity. A specimen of water of perfect apparent purity taken from a London pump, gave, on testing, 140 grains of different kinds of salts per gallon of water, whilst a sample taken from the Thames—considered bad enough—yielded, at the most, 20 grains of salts per gallon tested.

Of the preventions and remedies which have been proposed from time to time, it may be said their name is legion; they form the subject of a goodly number of patents. Among the preventives are various methods of filtration and purification by chemical processes, whilst the remedies consist chiefly of a variety of compounds best known as “boiler compositions.” Both these find supporters and objectors, and this arises from the fact that there are instances in which, either from accident or a judicious choice, selection is made of a remedy which proves suitable to the disease, whilst, on the other hand, an improper antidote is very often applied, it being frequently supposed that one description of boiler fluid, or other scale preventer, is applicable in all cases. Where water is found to form a rapid incrustation, it should be submitted to chemical analysis, the result of which would indicate the proper remedy. Apart from the doctoring processes, are several simple and inexpensive remedies which have proved very effective in preventing incrustation. One of these consists in placing small logs of oak, with the bark on, in the boiler, which has the effect of reducing the carbonate of lime to a kind of sludge, which falls to the bottom and thus preserves the boiler perfectly clean. This plan has been pursued by one of the London water companies for many years with perfect success. Mahogany sawdust has been employed with advantage for the same purpose as the oak logs. It acts in two ways—first, mechanically, by offering so many small points on which the carbonate and sulphate of lime may be deposited; and, secondly, by a peculiar action of the extractive matter in the wood. This applies more particularly to oak, especially when green, in which state it should be used. In North Wales the water used in boilers is often perfectly green, and oak sawdust is administered in considerable quantities. Chloride of ammonium will convert the lime salts into soluble compounds, viz: sulphate and carbonate of ammonia, and chloride of calcium; but in practice its use has not been very successful, owing to the sal ammoniac and ammoniacal salts acting on the brass-work. Where the action of a cure is only partial, as is the case with some boiler fluids, the remedy is worse than the disease. For instance, in some boilers at Woolwich supplied with Thames water, a certain composition was used in the hope of preventing incrustation. It was found that the composition

only acted upon the lighter portion of the sediment, leaving untouched the heavier and harder portion, which, though forming a much thinner deposit, was nevertheless impenetrable to the water, whilst, on leaving the lighter and heavier ingredients undisturbed, they were found to form a porous substance through which the water could reach the plates.

There can, of course, be no legitimate objection to the adoption of a remedy when a disease has been contracted, provided the remedy be appropriate. When the human system becomes deranged, recourse is had to medical aid. But a man of regular habit with an originally good constitution rarely requires the doctor. So with steam boilers—a well constructed boiler, with attention, need never be troubled with incrustation, except in rare instances. Prevention is at all times better than cure, and under all circumstances, where the construction of the boiler does not insure immunity, the most practical plan for the prevention of incrustation is the adoption of an efficient mode for blowing out. A more complete remedy, however, exists in the adoption of what is termed dry or surface condensation. But the benefits to be derived from judicious blowing-out are not generally realized, or there would not be the irregularity there is in the use of the blow-out apparatus. To be effectual in its operation it should be used at regular intervals during the day, the best time being whenever the engine is not at work and the water therefore at rest. Under these conditions the sediment has an opportunity of settling, whereas, at other times, it will be held in suspension by the rising bubbles of steam, when blowing-out will be comparatively useless. But, however regularly the operation may be performed, it cannot be effectual if confined to one point only in the boiler, when there is a heavy sediment. But the action may be distributed throughout the whole length of the boiler by having a perforated pipe carried from end to end. There are other ways by which the same result may be attained, but this arrangement has been found to answer the purpose exceedingly well. It sometimes happens that the lighter sediment will elude this apparatus, and will settle on the plates of the flues and shell. In such cases, by the use of scum pipes, it may be blown out whilst floating on the top of the water as scum, before it has time to adhere. The adoption of these pipes is the common practice in marine boilers, and might be judiciously applied to land boilers. It is a noticeable fact, although one not generally recognized, that overheating often occurs where no actual cake of deposit is formed. In many cases this may be due to the presence of thickening matter held in suspension in the water. Where the circulation is imperfect, or where there is no agitation, such as in a locomotive when running, the impediment presented by the sedimentary matter to the free escape of steam, doubtless lifts the water off the plates and so causes overheating. Instances are constantly occurring where overheating takes place with an ample supply of water, and where no incrustation is formed, such cases being chiefly confined to externally fired boilers.

A singular case of grease incrustation resulting in an explosion is

given by Mr. Longridge, the engineer of Steam Boiler Assurance Company in his last report. The case is worth noticing because it proves beyond doubt that explosions do occur from a cause which is little believed in. The boiler referred to was cylindrical, with hemispherical ends, made of $\frac{3}{8}$ -in. plates, in 1850, and had $2\frac{1}{2}$ -in. safety valves, weighted to blow off at 40 lbs. One day in last October, about noon, a loud report was heard, and the fireman was thrown down, steam and water issuing from the fire door at the same instant. On examination, it was found that about 8 ft. beyond the bridge there was a hole in one end of the plates of an irregular triangular form about 7 ins. in length, and 4 ins. in width at the base. Around the hole in the inside was an accumulation of deposit extending over an area of about $2\frac{1}{2}$ square feet, from 1 in. to $1\frac{1}{4}$ in. thick in the centre, and gradually reduced in thickness towards the outside. In other parts the boiler was almost free from deposit, but the surface of the plates had a greasy appearance, and at the back end there was a small patch of deposit of the same kind as that just mentioned. The deposit was found to be composed of grease and earthy matters, and on applying a light it ignited like a piece of wood. The formation of this deposit is due to the introduction of grease either by the attendant or in the feed water, which, it appears, at times conveyed greasy matter from soap works. The feed pipe delivered the water about fifteen inches from the centre of the hole in the plate on the side nearest the fire, and 10 ins. from the bottom of the boiler; the feed had been turned on about ten minutes previous to the accident, and the plate showed evidence of its cooling effect on that side. The conclusion is that, after the plate had become red hot, in consequence of the deposit, the latter had become loosened, and fracture taking place, water had intervened between the deposit and plate, producing a sudden generation of steam sufficient to cause rupture. It is a common practice to throw into boilers, old greasy cotton waste under the impression that it facilitates the removal of scale. But it is open to objection, inasmuch as the oil combines with impurities in the water and forms a greasy substance, which, when precipitated on the plates, prevents contact of the water and is thus the cause of overheating. It has, however, been found greatly to facilitate the cleaning of boilers if the plates were greased after every cleaning. For this purpose, in the royal gun factories at Woolwich, the refuse oil from the drip cans of the shafting is collected, and, after the boilers are cleaned, it is laid on inside them with a brush. Although this does not stop the incrustation it causes it to come off the plates much more readily, and is found to effect a great saving in time and expense in cleaning the boilers.

A simple method of depriving water of its earthy carbonates was successfully adopted in a small high pressure boiler. This was done by admitting a very small jet of cold water into the exhaust pipe of the engine, where, mingling with the waste steam, it condensed a portion of it. The steam, by raising the water to a boiling heat, drove off the free carbonic acid, and the neutral carbonates were thrown down on the sides of the pipe, which was made large enough to allow

it to accumulate. The water then ran down into a tank, whence it was pumped into the boiler at a temperature of about 200°. In addition to this, the partial condensation of the waste steam reduced the back pressure on the piston, and the result was a saving of half the fuel, the boiler remaining quite free from scale. But better than all these is the plan of using boilers properly constructed in the first instance, by which incrustation is reduced to a minimum, if not entirely prevented. By a properly constructed boiler is meant one so arranged that a proper circulation of the water is effected. In boilers thus designed such a thing as scaling is of very rare occurrence. Some eight and twenty years ago, a small circular boiler with water tubes was made by Mr. Hugh Greaves, we believe, the first of its kind in this country. Between the fire box and the outer case was placed a piece of sheet iron around the fire box and the tubes, by which means the circulation was completely established. After being in use twelve years the boiler was taken to pieces, and the fire box was scarcely coated, and the slight incrustation was clearly of very recent formation. In the Benson boiler, when worked with salt water, at high pressures, no incrustation takes place, owing to the rapid circulation of the water. The Field boiler, described in our number for February 17th, is another in which the principle of rapid circulation is fully developed and incrustation consequently prevented. In the Harrison or multispherical boiler this latter condition is secured by two-fold means, a double action being at work to hinder the formation of scale—first, the perfect circulation, and if that be insufficient, second, the alternate action of expansion and contraction. Scale being deposited whilst the spheres were heated, would, on their cooling and consequent contraction be broken up and thrown down. In marine boilers, incrustation was, at one time, a perplexing matter to deal with, as it was supposed to be impossible to prevent the boilers of a steamer from becoming salted up in some seas. But it has been ascertained that the saltiness of different seas varies but little, and however salt the water may be, the boiler can be preserved from any injurious amount of incrustation by blowing out as already noticed. This operation, to be effectual, should be performed very frequently, or a portion of the super-salted water may occasionally be allowed to escape. But, by proper blowing out, a very slight scale, at the most, will ever be found. There is no excuse for the engineer who allows his boiler to become damaged from incrustation.

For the Journal of the Franklin Institute.

A Body has no Weight while Falling freely by Gravity.

Gravity acts upon a body in an uninterrupted stream of force. While the body is at rest, this stream is incessantly entering, pervading, and *leaving* it. In doing this last, the force is as incessantly being destroyed by being equilibrated, or reacted against, by the equal op-

posing force of compression or of tension inherent in whatever other body keeps it at rest. This reaction of two forces is always attended by strain; that is, by either pushing or pulling; and in the case of a body at rest, the vertical *strain* which gravity produces, is called its *weight*.

But when a body begins to fall freely, or unresistedly, it instantly becomes converted as it were into a reservoir, into which all this stream of gravity becomes stored-up or accumulated, instead of being lost or destroyed as before. This stored-up force now becomes *motion* alone, without any strain, inasmuch as there is now no opposing force for it to strain or react against. Consequently, the body moves faster and faster, as the quantity of stored-up force gradually becomes greater.

This quantity of force, or, in other words, the quantity of force which produces motion in a given body, is directly proportionate to the velocity of the body; and since in a body falling freely *all* the force produces velocity alone without strain, the velocity becomes an absolute measure of the proportionate total quantities of force in it at different stages of its fall.

A body so falling for one second acquires a velocity of 32.2 feet per second; and at the end of two seconds, a velocity of 64.4 feet per second. Consequently, by the end of two seconds, there is stored up in it exactly twice as much force of gravity as at the end of the first second; and so on, according to the number of seconds. But if from the beginning of its fall the body retained stored up in it that increment of gravity also which had *previously* constituted its *weight*, this proportionality could not possibly exist; for at the end of the first second, the quantity of gravity in the body would be the sum of the weight and of the gravity accumulated during that second; and at the end of the second second, it would be the sum of the weight and of the gravity accumulated during two seconds; and the last of these sums would not be twice as great as the first. There is, therefore, no gravity in a body falling freely except that which enters it from the moment it begins to fall.

All the gravity in a body may exhibit itself either as weight or as motion, but not as both of these at the same time; for the same identical increments of force can never produce both strain and motion at the sametime. Therefore, the quantity which produces the strain called weight, cannot at the same time produce motion; nor can it while producing motion, produce weight also.

To a person at all conversant with the subject, the foregoing will of course appear to be nothing more than a useless play upon words, and in deference to the opinions of such persons, the writer would not have presented them. But inasmuch as the *Journal* is read by many purely practical men who find it difficult to divest themselves of the idea that there is in a falling body, a certain inherent property called weight, which assists gravity by some kind of pushing process in expediting its fall, he was induced to offer these remarks for their consideration alone.

J.

Action of Sea Water on Metals. By F. CRACE CALVERT, Ph.D., F.R.S.,
and R. JOHNSON, F.C.S.

From the London Mechanics' Magazine, March, 1865.

We were induced to examine the action exerted by sea water in consequence of the rapid changes which have taken place of late years in naval architecture, and especially in the substitution of metals and alloys for wood. To carry out the above views, we took twenty square centimetres of each metal, which we cleaned with great care and attention in order that the action of sea water might have its full effect; then two plates of each metal were placed in separate glass vessels, and immersed in equal volumes of sea water. After one month the plates were taken out, and any compounds that had adhered to the surface carefully removed; the plates were then dried and re-weighed, and the loss estimated. To render our results of more practical value, we have calculated the action of one hundred litres of sea water upon one square metre of each metal, and the following are the amounts in grammes of metals dissolved: steel, 29·16; iron, 27·37; copper, (best selected,) 12·96; copper, (rough cake,) 13·85; zinc, 5·66; galvanized iron, 1·12; block tin, 1·55; stream tin, 1·45; lead, (virgin,) trace; lead, (common,) trace. These results appear to us to lead to the following conclusions: 1. That the metal now most in vogue for ship-building, namely, iron, is that which is most readily attacked. 2. That this metal is most materially preserved from the action of sea water when coated with zinc, and, therefore, in our opinion, it would amply repay shipbuilders to use galvanized iron as a substitute for that metal itself. The above facts perfectly confirm those which we have already published in our paper, "On Galvanized Iron for Armor Plated Ships," in which it was shown, that when iron was in contact with oak they mutually acted upon each other, producing a rapid destruction of the two materials, whilst little or no action took place between galvanized iron and the wood. 3. The extraordinary resistance which lead offers to the action of sea water naturally suggests its use as a preservative to iron vessels against the destructive action of that element; and, although we are aware that pure lead is too soft to withstand the wear and tear which ships bottoms are subject to, still we feel that an alloy of lead could be devised which would meet the requirements of shipbuilders. Feeling that experiments made with a limited amount of sea water might not be a fair criterion of the action of the ocean upon metals, we repeated our experiments upon plates of forty centimetres square, which were immersed for one month in the sea on the western coast, (Fleetwood,) taking the precaution that they should be constantly beneath the surface of the water, and suspended by flax rope attached to a wooden structure, to prevent any galvanic action taking place between the plates and the structure to which they were attached. The following are the amounts in grammes of metals dissolved: steel, 105·31; iron, 99·30; copper, (best selected,) 29·72; zinc, 34·34; galvanized iron, 14·42; lead, (virgin,) 25·69; lead, (common,) 25·85. The above figures suggest the following remarks: That the action has

been much more intense, in this instance, than when the metals were placed in a limited amount of water in the laboratory. These results are due probably to several causes acting at the same time, viz : that the metal was exposed to the constantly renewing surface of an active agent ; and there was also a considerable friction exerted on the surface of the plate by the constant motion of the water, there being at Fleetwood, a powerful tide and rough seas. What substantiates this opinion is, that the lead plates undoubtedly lost the greater part of the weight, not by the solvent action of the sea water, but from particles of lead detached from them, in consequence of their coming in contact with sand and the wooden supports to which they were attached ; but this cause of destruction having been observed with lead plates, it was afterwards carefully guarded against in the case of all the other metal plates.

We also deemed it desirable to examine the action of sea water on various brasses. We therefore immersed for one month, plates of various alloys in that fluid, and the following are the results of the action of two hundred litres of sea water upon one square metre surface of the following brasses :

Composition of Brasses.			Quality of Metals Dissolved.			
			IRON.	COPPER.	ZINC.	TOTAL.
Pure copper, . . .	50.0		—			
Pure zinc, . . .	50.0					
	100.0			1.110	10.537	11.647
Commercial brass :						
Copper, . . .	66.0					
Zinc, . . .	32.5					
Iron and lead, . .	1.5					
	100.0		0.579	3.667	3.324	7.570
Muntz metal, (sheet) :						
Copper, . . .	70.0					
Zinc, . . .	29.2					
Iron and lead, . .	0.8					
	100.0		0.438	4.226	2.721	7.385
Muntz metal, (bars) :						
Copper, . . .	62.0					
Zinc, . . .	37.0					
Lead and iron, . .	1.0					
	100.0		0.501	2.697	3.493	6.691
Prepared brass :						
Copper, . . .	50.0					
Zinc, . . .	48.0					
Tin.	2.0					
	100.0		TIN. 0.365	7.04	3.477	10.882

These results show how very differently sea water acts upon divers brasses and the influence exercised upon the copper and zinc composing them by the existence in them of a very small proportion of another metal ; thus, in pure brass the zinc is most rapidly dissolved, (which, *en passant*, is the contrary to what takes place in galvanized iron,) whilst it acts as a preservative to the copper. Tin, on the other hand, appears to preserve the zinc, but to assist the action of sea

water upon the copper. The great difference between the action of sea water upon pure copper and upon Muntz metal seems to us to be due not only to the fact that copper is alloyed to zinc, but to the small proportion of lead and iron which that alloy contains; and there can be no doubt that shipbuilders derive great benefit by using it for the keels of their vessels.

We were so surprised at the inaction of sea water upon lead, that we are induced to compare its action with that of several distinct varieties of water, viz: Manchester Corporation water—well water—distilled water in contact with air—the same deprived of air; and the following are the amounts of metal dissolved by two hundred litres of these waters upon one square metre of surface during eight weeks; the amounts are given in grammes. Manchester Corporation water, 2·094; well water, 1·477; distilled water, (with air,) 110·003; distilled water, (without air,) 1·829; sea water, 0·038. These figures require no comment, as they confirm our previous result that sea water has no action on lead.

Mr. John Robinson exhibited specimens of iron and brass which had been acted upon by the water of the river Medlock, and stated he had found that an alloy of lead, tin, and antimony resisted the action of sea water better than any other metal or alloy he had tried.

On Chemistry Applied to the Arts. By Dr. F. CRACE CALVERT,
F.R.S., F.C.S.

From the London Chemical News, No. 249.
(Continued from vol. I., page 406.)

LECTURE VI.

FLESH, its chief constituents, boiling and roasting. *Animal black*, its manufacture and applications. Various methods of preserving animal matters. Employment of animal refuse in the manufacture of *prussiate of potash*. A few words on the decay of organic matters, and their fermentation and putrefaction.

It will be easily understood by those who have done me the honor of attending this course, that this last lecture must touch upon a variety of topics, in order to give an idea of some of the applications which animal matters receive, and which yet remain to be discussed.

Flesh.—M. Chevreul, in 1835, and Baron Liebig, in 1845, examined the changes which flesh undergoes when placed in contact with hot and cold water; and the following table, taken from Liebig's interesting work on the chemistry of food, will give you an idea of the composition of flesh:

Cold water.					Action of boiling.				
Soluble,	.	.	.	66	{	Coagulated albumen,	.	29·5	
						Gelatine,	.	6·0	
						In solution,	.	30·5	
						Fibres and membranes,	.	164·0	
Insoluble,	.	.	.	164					
Fat,	.	.	.	20					
Water,	.	.	.	750					
					1000				

Liebig and Chevreul further succeeded in isolating, of the 30 parts soluble in water, some of the following substances :

Kreatine, ...	C ₈	H ₉	N ₃	O ₄ + 2 H O
Kreatinine, ...	C ₈	H ₇	N ₃	O ₂
Sarcosine, ...	C ₆	H ₇	N ₃	O ₄
Inosinic acid, ...	C ₁₀	H ₆	N ₂	O ₁₀
Lactic acid, ...	C ₆	H ₅	O ₅	+ H O
Guanine [Scherer], ...	C ₁₀	H ₅	N ₅	O ₂
Xanthine [Strecher], ...	C ₁₀	H ₄	N ₄	O ₄
Glycocoll, ...	C ₄	H ₅	N	O ₄
Leucine, ...	C ₁₂	H ₁₃	N	O ₄
Osmazome, ...				

The most important mineral salts in flesh are the acid phosphate and lactate of lime, and, according to Fremy, the acid phosphate of potash and chloride of potassium. The above statement shows that flesh is a most complicated substance, and it is easy to conceive that this must be so, when it is remembered that it is derived from blood, of which it contains a large amount; but a most interesting and curious fact is, that whilst blood is rich in salts of soda and poor in salts of potash, in flesh the relative proportion of these salts is directly reversed. Another interesting fact is the small amount of solid matter contained in flesh, and also the small amount of nutritive matter it yields to water under the most favorable circumstances. I repeat "the most favorable circumstances," for when meat is placed in boiling water, the 3 per cent. of albumen it contains is coagulated, closing the vessels of the flesh, and preventing all further exit of the fleshy fluids, and such should be the case when meat is intended to be eaten as boiled meat, and is properly cooked; but when the object in view is to extract the whole of the matter soluble in water, as in the preparation of beef tea, then the meat should be cut in small pieces, and brayed in a mortar with water, the whole then thrown into clean linen and pressed. The juice of the flesh so obtained should then be carried just to the boil, again passed through the strainer, and, after the addition of a little common salt, will be ready for the patient. Beef tea, even prepared by this process, which is certainly the best to my knowledge, contains, as the table above shows, but a small quantity of nutritive matter, there being only a little gelatine and a small proportion of the other substances named above. Chevreul attributes the odor of beef tea and meat soups to osmazome, and Liebig to kreatine; in fact, Liebig considers kreatine to be one of the essential substances characterising the aroma of various kinds of flesh. Liebig, during his researches on this substance, succeeded in obtaining from

Fowls' flesh, ...	8.21 of kreatine.
Ox heart, ...	1.37 "
Pigeon, ...	0.82 "
Beef, ...	0.69 "

Further, he observed, that the flesh of wild animals contained a much larger proportion of kreatine than those which were confined; for instance, that there was six times as much in the flesh of a wild fox as in that of a tame one. Allow me to say a few words on the properties of this curious substance, which presents itself in the form of mode-

rately large white rectangular prisms, having a pearly lustre, soluble in water, insoluble in alcohol; and although this substance is neutral, it is converted, when heated with hydrochloric acid, into another solid crystallized substance called kreatinine, which possesses strong alkaline properties. When kreatine, instead of being treated by an acid is acted upon by baryta, it is converted into an acid compound called inosinic acid. Liebig ultimately succeeded in finding these substances, as well as another called sarcosine, in various animal secretions. I shall not take up more of your time by discussing the chemical properties of these substances, but merely state that they enable us to distinguish real soup tablets from spurious ones. For this purpose a solution of the tablet in cold water should be made, when, if genuine, it will give a precipitate with chloride of zinc, whilst the spurious one, which contains gelatine but no kreatine, will not do so. Another reaction is, that the pure article will yield 85 per cent. of its weight to alcohol, whilst the imitation will only yield about five.

Preservation of meat and animal substances.—A low temperature is most favorable to the preservation of flesh and other animal substances; it will not enter into putrefaction, the best proof of which is that elephants in a perfect state of conservation have been found in Siberia, buried in ice, where they have doubtless existed for many thousands of years. It is also well known that the inhabitants of polar regions preserve their meat fresh by burying it in snow, and I mentioned an instance in one of my previous lectures, viz: the preservation and bleaching of sturgeons' bladders on the banks of the Volga. A high state of dessication or dryness, also contributes powerfully to the prevention of decay. Thus in Buenos Ayres and Monte Video, meat is cut into thin slices, covered with maize flour, dried in the sun, and consumed largely, under the name of tassago or charke, by the inhabitants of the interior, and also by the black population in Brazil and the West Indies. Further, dried meat reduced to powder is used by travelers in Tartary and adjacent countries, and I may add, that of late years, meat biscuits have been extensively consumed by the emigrants having to travel from the United States to California, and the West Coast generally. It is stated that six ounces per diem of this meat biscuit will maintain a man in good health throughout the journey. A remarkable instance of the preservation of animal matter by extreme dessication is related by Dr. Wefer, who states that in 1787, during a journey in Peru, he found on the borders of the sea, many hundreds of corpses slightly buried in the sand, which, though they had evidently remained there for two or three centuries were perfectly dry and free from putrefaction. Although it is not within the scope of these lectures to describe the preservation of vegetable matters, still, I cannot refrain from mentioning the interesting method adopted by MM. Massan and Gannal, by which, as you are doubtless aware, vegetables are preserved in the most perfect manner. The process is most simple, as it consists in submitting the vegetables for a few minutes to the action of high pressure steam, (70 lbs. to the square inch,) then drying them by air heated to 100°, when, after compression by

hydraulic pressure, they are made into tablets for sale, and when required for use it is only necessary to place the tablets for five hours in cold water, when the vegetable substances swell out to their former size and appearance and are ready for cooking. As the presence of oxygen or air is an essential condition of putrefaction, the consequence is that many methods have been invented to exclude that agent, or rather, as I shall show at the end of this lecture, the sporules or germs of cryptogamic plants or animals, which are the true ferments or microscopic source of fermentation and putrefaction. Permit me to describe concisely some of the methods proposed, and I believe that one of the best processes for excluding air was that invented by Appert, in 1804. It consists in introducing the meat or other animal substance with some water into vessels which are nearly closed; these are then placed in a large boiler with salt, (which raises the boiling point of the liquor,) and the contents of the vessels are kept boiling for about an hour, so as to exclude all air, and destroy, by the high temperature, all the sporules or germs of putrefaction they may contain, when they are hermetically closed. M. Chevalier Appert has improved this process in placing the prepared vessels in a closed boiler, by which means he raises the temperature (by pressure) to 234° , which effects the same purpose more rapidly and economically. To give you an idea of the extent of this trade, I may state that M. Chevalier Appert prepared above 500,000 lbs. of meat for the French Army in the Crimea. I am aware that many modifications have been applied to this process, but I shall only mention that of Mr. G. M'Call, who adds to the previous principle of preservation a small quantity of sulphite of soda, well known to be a powerful antiseptic. The beautiful specimens now on the table, which have been kindly lent to me, by Messrs. Fortnum and Mason, and by Mr. M'Call, will satisfy you of the applicability of the above named methods for the preservation of meat and other animal substances. But before concluding this part of my lecture, I must add that the preservation of animal and vegetable substances by the exclusion of air and cryptogamic sporules is also effected by other methods than those above described; for instance, they are imbedded in oil, or in glycerine, as suggested by Mr. G. Wilson, or into saccharine syrups. I should not forget to mention that several plans have been proposed for protecting animal matter by covering their external surfaces with coatings impermeable to air. Two of the most recent are the following: M. Pelletier has proposed to cover the animal matter with a layer of gum, then immersing it in acetate of alumina, and lastly, in a solution of gelatine, allowing the whole to dry on the surface of the animal matter. The characteristic of this method is the use of acetate of alumina, which is not only a powerful antiseptic, but also forms an insoluble compound with gelatine, thus protecting the animal matter from external injury. Mr. Pagliari has lately introduced a method which is stated to give very good results. It consists in boiling benzoin resin in a solution of alum, immersing the animal matter in the solution, and driving off the excess of moisture by a current of hot air, which leaves the above antiseptics on the animal

matter. It is scarcely necessary to mention the old method of using smoke arising from the combustion of various kinds of wood, except to state that in this case it is the creosote and pyroligneous acid which are the preservative agents. The preservation of animal matter by a very similar action is effected by the use of carbolic acid a product obtained from coal tar. It is much to be regretted that this substance, which is the most powerful antiseptic known, cannot be made available for the preservation of organic substances intended for use in arts and manufactures; no cheaper or more effective material can be found. For example, I have ascertained that one part of carbolic acid added to five thousand parts of a strong solution of glue will keep it perfectly sweet for at least two years, and probably for an indefinite period. Also, if hides or skins are immersed for twenty-four hours in a solution of one part of carbolic acid to fifty of water, and then dried in the air, they will remain quite sweet. In fact, hides and bones so prepared have been safely imported from Monte Video. From these facts and many others, with which I am acquainted, I firmly believe that this substance is destined, within a few years, to be largely used as an antiseptic and disinfectant. I need hardly speak of the power of chloride of sodium, or common salt, in preserving animal matters, and it is highly probable that the interesting process described to you on the 13th April, by Mr. J. Morgan, for the employment of salt, is likely to render great service in preserving animal food from putrefaction. But with regard to the feasibility of its use in Monte Video and Buenos Ayres, I cannot offer an opinion, as it depends upon so many local circumstances which it is impossible to appreciate here. Messrs. Jones and Trevethick, displayed at the last Exhibition, some meat, fowls, and game preserved by the following process, which received the approbation of the jurors. Meat is placed in a tin canister, which is then hermetically closed, with the exception of two small apertures in the lid. It is then plunged into a vessel containing water, and after the air has been exhausted through one aperture by means of an air pump, nitrogen is admitted through the second aperture, and the alternate action of exhausting the air and replenishing the nitrogen is kept up until the whole of the air has been removed. The nitrogen in its turn is exhausted, and sulphurous acid gas admitted. The two apertures are then soldered up, and the operation is completed. As I consider the action of carbon on animal matters rather as a case of oxydation than of preservation, I shall refer to that subject further on, and shall, therefore, proceed to consider the employment of certain animal matters not yet alluded to during this course of lectures, such as the flesh of dead animals not used as food, and those other parts of their carcasses which have not been applied in any of the processes already described. The greatest part of these refuse matters are used for producing animal black, which differs from bone black, referred to in my first lecture, being used in the state of impalpable powder, whilst bone black or char is composed of small hard grains. The manufacture of animal black is generally carried out by introducing into horizontal retorts connected with a coil or condenser, and with an exit

pipe for the gases, some of the animal matters mentioned; on the application of heat, decomposition occurs, the oily matters distil and condense in the worm, and constitute what is called Dippel's oil formerly much used in the art of currying certain classes of leather; water also distils, charged with a variety of ammoniacal salts, which are generally converted into sulphate of ammonia for agricultural purposes. As to the gases, they are usually ignited and burnt to waste. The carbonaceous mass which remains in the retort is removed, and ground to powder in a mill with water, and allowed to settle, and, lastly, dried and sold under the name of animal black. Its chief uses are in the manufacture of blacking and printing ink. Another manufacture which consumes a large quantity of animal refuse especially the horns, hoofs, &c., of too inferior a quality to be used for the purposes described in my first lecture, is that of the yellow prussiate of potash, a most important salt, for it is extensively used in calico printing, silk and wool dyeing, and in the manufacture of the pigment called prussian blue, for gilding silver, copper, and other inferior metals; and, lastly, it is the source from which cyanide of potassium is procured, a substance much employed in the art of photography. Let me now call your attention to the manufacture of prussiate of potash, the greatest portion of which is prepared at the present day, still by the old process devised by Dr. Woodward, F.R.S., in 1724. It consists in introducing into cast iron pots, American pearlash, melting it, closing the vessel, and then setting the mass in motion by means of a revolving shaft. At this period of the operation, hoofs, horns, and other animal refuse, are introduced in small quantities at a time. Under the influence of heat and of the alkali, the nitrogen of the organic matters splits into two parts, one part combining with the hydrogen to form ammonia, which escapes, whilst the other portion unites with the carbon, producing cyanogen, which remains combined with the potassium of the potash. After several hours the operation is considered to be completed, and the melted mass is run out into small cast iron receptacles; when cool these are placed in large vats with water, and a jet of steam is introduced, and the whole is kept on the boil for several hours, when the cyanide of potassium is partly decomposed, giving rise to carbonate of potash and to cyanide of iron, for not only has a portion of the iron of the melting pots been attacked and combined with the mass, but a certain quantity of iron filings have been used during the operation. However, two parts of the cyanide of potassium combine with one part of cyanide of iron, and the result is that a double cyanide, called ferrocyanide of potassium, or yellow prussiate of potash, is formed. The liquors are then allowed to clear by standing, and the aqueous solution is evaporated until a pellicle appears on its surface, when it is allowed to cool, and the salt is deposited on strings which have been passed through the crystallizing vat, and which facilitate the crystallization of the prussiate salt. In consequence of the large amount of animal matter used as compared with the quantity of prussiate obtained, this salt has always commanded a good price in the market, and has induced many eminent

chemists to try to devise cheaper processes for obtaining it. To attempt here to give merely an outline of these various proposed plans would involve so much technical description as would occupy far too much time for this lecture, but I would recommend those interested in this branch of manufacture to read the learned account given by Dr. A. W. Hofmann, in his report on "The Chemical Products in the last Exhibition," page 57, where they will find the process of M. Gauthier-Bouchard for obtaining salts of cyanogen from the ammoniacal waters of gas works; those of Mr. R. T. Hughes and Messrs. Bramwell, of Newcastle, for the conversion of nitrogen of the atmosphere into cyanide of potassium; that of M. Kamrodt, for decomposing ammonia to carbon carried to a high temperature; and, lastly, that of MM. Margueritte, and De Sourdeval, for producing cyanogen from the nitrogen of the atmosphere and fixing it by means of barium. This latter process seems to be highly commended by the learned reporter to whom I have referred. I must not, however, omit to mention the scientific and interesting process devised by M. Gelis, and based on the chemical reaction which ensues when bisulphide of carbon is mixed with sulphide of ammonium. Yellow prussiate crystalizes in large crystals belonging to the octohedral system, composed, as before stated, of two parts of cyanide of potassium, 2CyK , and one of iron, $\text{CyFe} + 3$ of water or HO . This salt is freely soluble in water but is insoluble in alcohol, and when mixed with weak vitriol and heated gives rise to prussic acid, which distils, and may be used as a violent poison, or, in qualified hands, as a most valuable therapeutic agent. When ferrocyanide of potassium is heated with several times its bulk of concentrated sulphuric acid, instead of yielding prussic acid, as above, it gives rise to a poisonous gas, called oxide of carbon, which burns with a beautiful blue flame, and which we have all seen burning in some fireplaces when the combustible matter has lost all its volatile constituents and nothing remains but a red incandescent mass. When chlorine is passed through a solution of this salt chloride of potassium is formed, and the yellow prussiate is converted into red prussiate or ferriecyanide of potassium, composed of $3\text{CyK} + 3\text{Fe}_2\text{Cy}_3$. When heated with peroxide of mercury, potash, peroxide of iron, and cyanide of mercury are produced, the latter being a most violent poison. To produce Prussian blue on silk with this salt, all that is required is to dip the silk in a slightly acidulated liquor containing a persalt of iron, and when the silk is washed and mordanted, it is dipped in a weak acidulated solution of yellow prussiate of potash, when it assumes a beautiful blue color due to the formation of Prussian blue. To dye wool, it is necessary to pass it through a boiling bath composed of yellow prussiate, muriate of tin, and a small quantity of sulphuric acid. Prussian blue is gradually formed, and fixes itself on the fibre. To produce blues on calicoes, a solution of yellow prussiate of potash is made, to which is added some tartaric acid and muriate of tin. This mixture, after being properly thickened, is printed on the calico, and then submitted to the action of steam, the Prussian blue so produced being fixed on the cotton fibre, by means of the oxide of tin, resulting from the decomposition of the salt employed.

Nothing is more simple than to gild or silver metals by means of ferrocyanide of potassium, or to cover iron and other metals with copper. To obtain a gilding liquor, it is only necessary to take 1000 parts of water, adding to it 100 parts of yellow prussiate of potash, 10 parts of chloride of gold, and one part of caustic potash. Each of these should be added successively, and the whole of the liquor carried to the boil and filtered. It is then ready for gilding silver or brass objects, when properly attached to the pole of a galvanic battery. The silvering liquor is made by substituting for the chloride of gold, in the above process, ferrocyanide of silver, prepared by adding nitrate of silver to a solution of ferrocyanide of potassium, the white precipitate resulting being washed and added to the liquor intended for silvering. For covering zinc or iron with copper, it is simply necessary to substitute the ferrocyanide of copper for that of silver. Ferrocyanide of potassium, as above stated, is also employed for the manufacture of Prussian blue, which was accidentally discovered by Diesback, in 1718, by adding alum, containing iron, to the ammoniacal liquors sold to him by Dippel, which were produced as already stated above, during the distillation of animal refuse. These liquors, being rich in cyanide compounds, yielded with the salt of iron of the alum, Prussian blue. At the present day, Prussian blue is manufactured by different processes, but they are all based on the principle of mixing various salts of iron with red or yellow prussiate, when double cyanides of iron (or Prussian blues) are produced.

(To be continued.)

On a Means of Increasing the Resistance to Rupture of Hydrostatic Cylinders. By ST. JOHN V. DAY, C.E.

From the *Practical Mechanic's Journal*, November, 1865.

Hitherto it has been generally assumed that the immediate cause of rupture in hydrostatic cylinders is the pressure of the fluid against their internal walls. Primarily this is the fact, but by careful observations upon the structure of cast iron, of which materials these cylinders are usually, if not always, made, it has been asserted, that although the cause of rupture has its origin with the concentration of external force within the cylinder walls, yet there is reason, as will hereafter be seen, to believe that, carried to the extent it is usual to employ in practice, this, of itself, is not sufficient to produce complete disruption of the mass.

It has long been known that cast iron, when cooled in large masses (such as hydrostatic cylinders, guns, &c.,) has always its portions towards the centre of a density much inferior to that at and approaching to its outward surface; and, although this inferiority may be much reduced by running the metal into the mould, and allowing it to cool under the pressure of a static head of fluid metal, as proposed and experimented upon by Mr. Mallet, in 1840,* still it must ever remain

* Trans. British Association, pp. 304 and 305; Construction of Ordnance, Arts. liv., lv., lvi., and lvii.

an impossibility to bring up the tenacity of the interior portions of a heavy cylinder equivalent to those further from its centre. The laws of cooling themselves, at least, render it impossible, however much the ingenuity of mechanics may, by the introduction of abnormal circumstances, modify them so that the permanent irregularities of stress may be diminished.

This acknowledged deterioration of the tensile value of cast iron under the conditions above mentioned, has led to a large amount of investigation, both theoretically and experimentally, on the part of the ablest mathematicians and mechanics, amongst whom, under the first head, may be mentioned, Barlow, Lamè, Rankine, and Hart; under the second, Mallet, Longridge, and others. By the first named of the class, a formula has been proposed, and which has been modified by the others, tending towards an accurate expression for the tenacity of any given cylinder of cast iron; in all probability that of Professor Rankine approximates most closely to the truth.* Various values for the reduction of strength in large castings have been given by those whom we have mentioned under the second head, viz: Mr. Longridge stated, "he felt confident that in a mass of metal, such as that required for a 68-pounder gun, the loss of strength would be at least fifty per cent."† the same author further on remarks: "When that was combined with the loss of strength due to a homogeneous cylinder, it easily explained the bursting of hydraulic presses."‡

This initial drawback to the employment of iron in thick castings, has induced engineers at different periods to suggest, and in many instances adopt means for artificially strengthening them, which, in the case of hydrostatic cylinders and ordnance, has been effected in some instances by shrinking on their exterior, tubes or hoops of malleable iron, or in others by enveloping them in a series of coils of wire. But whatever the objections may be to manufacturing cylinders in this manner one thing is certain, that for hydrostatic presses it has but in a few instances been restored to.

Referring again to Mr. Longridge's paper, we find it there stated, in reference to a hydrostatic press cylinder of ten inches diameter, that, using the " formulæ of Lamè, afterwards deduced by Dr. Hart in his calculations for Mr. Mallet, and by Mr. C. H. Brooks for the author, also arrived at by Professor Rankine by another method, the bursting strength would be $3\frac{1}{2}$ tons per square inch."§

It will not be denied that, up to the present time, it has been impossible to obtain ordinary cast iron cylinders of large size to resist a pressure of three or four tons per square inch—the aggregate of cylinders annually ruptured at a lower pressure fully bear out this conclusion.

The author's attention has recently been drawn to the consideration of certain observations which have been carried on for some time by Messrs. Weems, engineers, of Johnstone, near Glasgow, relative to

* Applied Mechanics, Art. 273.

† Transactions of the Institution of Civil Engineers, vol. xix., Session, 1859–60.

‡ Ibid.

§ Ibid.

the rupturing action of water as it obtains ingress to the intermolecular spaces of hydrostatic cylinders. It is held by these gentlemen, that the entrance of the water into the substance of the cylinder is in effect equivalent to slicing off a ring of the metal either inside or outside, thereby proportionately reducing its resistance to internal fluid pressure. The action of the water may be referred to an annular series of wedges inserted into every possible crevice in the cylinder's walls, and driven in to rend the cylinder, so that, as each wedge penetrates the substance, the tenacity of the substance is proportionately reduced; similarly the greater the pressure the consequently greater distance will the water obtain vent into the cylinder's substance, when rupture is very easily brought about, the extent of entrance of the liquid also depending, under any given pressure, upon some function of the density of the iron as the exterior surface is reached.

Putting x to represent the distance that the water would enter the cylinder's substance under any given pressure, d the density of the material, and φ the function of increased density as the cylinder's exterior limit is reached, then—

$$x \propto \varphi (d).$$

It is a fact that under moderate pressures, water always does find its way completely through so porous a substance as cast iron, and distributes itself over the surface, at first in the form of very fine particles, which by and by aggregate, and may be seen to run like rain drops, in lines extending downwards. Taking it for granted, (as the firm before referred to have done,) that this interstitial entrance of the fluid diminishes the tenacity of the material, it was next sought to obstruct the passage of the water, and from the results that have been and are being obtained, a doubt cannot remain that this difficulty has been speedily and successfully overcome, and that ordinary hydrostatic cylinders may thereby be rendered considerably stronger within their usual working limits. The remedy for this evil consists in placing a very thin lining of a material having great density, and consequent high impermeability, between the liquid and the cylinder—that is, a thin cylinder fitting closely to the bored interior of the ordinary cylinder. The material used for this purpose so far has been copper.

We now have to show whether any truth existed in the previous considerations relative to the supposed injurious influence of the intermolecular entrance of liquid. If the tested cylinders had burst at the same pressure that unlined cylinders had previously done, it is clear that the expense and trouble of lining would have been worse than useless; but this is not the case. Hitherto an ordinary hydrostatic cylinder, unless strengthened externally, having a ram of 24 inches diameter, could not be relied upon at a pressure much above two tons per square inch—certainly not above 2.5 tons. A cylinder of this diameter, bored out and lined as we have previously explained, has been for a long time, and now is working at a constant stress of 3.5 tons, for the manufacture of metallic pipes; and Messrs. Weems believe this press to be perfectly safe at this strain for any reasonable

length of time. Until the introduction of the copper lining they found it impossible to obtain cylinders sufficiently strong to resist the pressure necessary for the manufacture of metallic pipes. The same firm have a 33-inch cylinder also used in the manufacture of metallic pipes, and constructed in the same manner; but we do not know what they consider to be the safe working limit in this instance. That the theory here broached is no myth, is evident from the number of presses that are being constructed on the system in and around Glasgow.

The view set forth is one that for a time may meet with opposition, and it may yet receive another explanation, having reference to a chemical rather than a mechanical cause; probably the exact truth lies in combination of both. It is generally known amongst engineers that if the natural surface is removed from a piece of cast iron, and that in this state it is exposed to atmospheric influences, or is placed so that steam or mist becomes condensed on the exposed surface, in a short time oxidation will have taken place to some distance below the surface, and the tenacity of the iron become diminished in a ratio depending upon the difference of strength of corresponding sections of unoxidated and oxidated portions; in a given specimen the tenacity will vary as a function of the depth to which the oxygen has reached. It is almost certain that after a withdrawal of interior fluid pressure, the elasticity of the cylinder acting on the intermolecularly held particles of water causes them, or a great portion of them, to be extruded, and thus a large portion of the space they occupied is left partly empty, at which time, in all probability, the oxygen attacks the tiny pillars by which each interstice may easily be conceived to be surrounded. As this action goes on, so the tenacity of the cylinder is rapidly reduced, and, as hitherto, breakdown after breakdown has been a continual annoyance and endless expense.

On the Construction of Blast Furnaces and the Manufacture of Pig Iron in the Cleveland District. By Mr. JAMES GEORGE BECKTON, of Whitby.

From Newton's London Journal of Arts, August, 1865.

Within the last ten years, the blast furnaces which have been erected in the Cleveland district have been gradually increased in size, both in diameter and height; and these alterations have thus far been attended with good results, so much so, that almost all the new furnaces, now in course of erection, are being built with boshes, ranging from 16 feet to $22\frac{1}{2}$ feet in diameter, and from 60 feet to 75 feet in height, from the bottom of the hearth to the filling plates at the top. Previously the furnaces ranged from 13 feet to 15 feet diameter at the boshes, and from 45 feet to 50 feet in height, the extreme increase being about 70 per cent. in both dimensions. The maximum diameter of the boshes appears not yet to have been attained; and the limit to the height will apparently be found in the strength of the coke to support the crushing force of the high column of materials in the large blast furnace. The

make of pig iron has increased at the same time from 200 tons per week in the small furnaces to 300 tons in the large furnaces.

The average quantity of materials used in the production of one ton of pig iron in the large furnaces is as follows :

26	cwt. of Durham coke,
70	" Cleveland ironstone,
15	" of limestone,
10	" of coal for boilers, hot-blast stoves, and calcining kilns,

121 " total,

or about 6 tons of materials per ton of iron made. Formerly the quantity of coke used, per ton of iron made, averaged 35 cwt., instead of 26 cwt., and the quantity of coal 20 cwt., instead of 10 cwt. The writer does not attribute the whole of the saving of fuel which has taken place to the increased size of the furnaces alone, as there are several other improvements which have combined to produce an economy of fuel in the manufacture of pig iron in the Cleveland district, of which the following are some of the principal :

First.—The more efficient management which has taken place at the different works.

Second.—The better adaptation of engine power and hot-blast stoves to the requirements of the furnaces.

Third.—The improved system of calcining the ore, which was formerly carried on by clamping in the open air, but is now performed in properly constructed calcining kilns.

Fourth.—The higher degree of temperature of the blast supplied to the furnaces, which was formerly heated in the hot-blast stoves to only 600° or 700° Fahr., but is now very generally being supplied to the furnaces at a temperature of from 800° to 900°.

Fifth.—The plan of taking off the waste gas from the furnaces and burning it at the boilers and hot-blast stoves, in place of using additional coal for this purpose.

The application of the waste gas to the boilers and hot-blast stoves is becoming very general at the different works in the district, and arrangements are now being made at several of the new works in course of erection for applying it to the calcining kilns, for the purpose of calcining the ironstone. The plan in general use for taking off the gas from the blast furnace is the closed furnace top with bell and hopper, sufficiently large to charge from 8 to 10 tons of materials into the furnace at once, and with an arrangement for raising and lowering the bell by hand. The impression seems to be gaining ground that taking off the gas with the closed top, and in connexion with a large chimney double the height of the furnaces, does not interfere with the operations of the large furnace, either as regards economy of fuel or quality and make of iron.

A noticeable feature in the large furnaces is the greater amount of time the materials are allowed to remain in the furnace. The capacity of the Thornaby furnaces, with 20 feet boshes and 60 feet height, is 12,361 cubic feet ; the area of the boshes is 314 square feet, and the make of iron 300 tons weekly per furnace. The capacity of the small

furnaces which were formerly erected, with 14 feet boshes and 50 feet height, is 5553 cubic feet; the area of the boshes is 154 square feet, and the make of iron 200 tons weekly per furnace. In the large furnace, therefore, there are more than twice the quantity of materials undergoing the process of heating, and also remaining a longer time in the furnace. Moreover, the area of the boshes in the large furnace being double that in the small furnace, while the quantity of iron produced by the large furnace and, consequently, the quantity of blast supplied is only one and a half times as much as in the small furnace, it follows that the ascending gases pass through the materials at a slower velocity and at a lower temperature in the large furnace. This allows the coke to descend to the zone of fusion without losing so much of its carbon in the formation of carbonic oxide, as previously in the small furnace; and hence arises the greater economy of fuel in the large furnace. To produce 300 tons of pig iron per week, the large furnace requires to be supplied with 8000 cubic feet of blast per minute, at a pressure of 3 lbs. per square inch.

Four furnaces at the Ormesby Iron Works, Middlesborough, belonging to Messrs. Cochrane, erected in 1855, were the largest in the district at that time: the boshes are 16 feet diameter, and the height is $56\frac{1}{2}$ feet. The furnaces are constructed upon land consisting of mud and silt, and piling had therefore to be resorted to, in order to secure a good foundation for the furnaces. A bed of concrete was placed on the top of the piles, and six inverted arches were turned on the top of the concrete and the brick pillars carried up, and strong cast iron bearers fixed across the top, for carrying and binding the brick-work of the barrel and boshes. The outer shell is bound with wrought iron hoops, fixed near enough together to prevent the barrel from cracking. The boshes are at an angle of 75° from the horizontal.

In building four furnaces, in 1858, at the Jarrow Iron Works, Newcastle-on-Tyne, a good strong clay was found for the foundations to rest upon; the brick-work was carried up to the floor line, then twelve cast iron columns were erected, and wrought iron casings fixed on the top of these. The casings extend from the top of the five tuyere houses to the top of the boshes, above which the barrel is bound with wrought iron hoops supported by T irons, the latter being carried up to the top, and a flat ring riveted to them sufficiently strong to carry the floor plates. The boshes are 18 feet diameter, at an angle of 66° from the horizontal, and the furnaces are 60 feet high.

At the Normanby Iron Works, Middlesborough, belonging to the Messrs. Jones, Dunning & Co., three furnaces were erected in 1860, upon a bed of concrete on clay of a weak nature; they are supported on brick pillars, and hooped similarly to the Ormesby furnaces. The boshes are 18 feet diameter, at an angle of 72° from the horizontal, and the furnaces are 58 feet high.

At the Thornaby Iron Works, South Stockton-on-Tees, belonging to Messrs. Whitwell, three furnaces were erected in 1862 upon piles, in consequence of the land being mud and silt; they stand each upon 12 cast iron columns, and are cased with iron, similarly to the Jarrow

furnaces. The boshes are 20 feet diameter, at an angle of 68° from the horizontal, and the furnaces are 60 feet high.

At the Acklam Iron Works, Middlesborough, by Messrs. Stevenson, Wilson, Jacques & Co., three furnaces are being built on piles, in consequence of the land being mud and silt, and are each supported by 12 cast iron pillars. The brick-work around the boshes is cased with plates, and from the boshes up to the top the barrel is bound with hoops and T irons. The boshes are $22\frac{1}{2}$ feet diameter, at an angle of 68° from the horizontal, and the furnaces are 70 feet high. These furnaces the writer believes to be the largest in dimensions that have ever been erected, and their contents will amount to no less than 1250 tons of materials per furnace. They are expected to produce each 350 tons of pig iron per week.

Mr. D. Adamson regretted that Mr. Beckton was unexpectedly prevented from being present at the meeting. With some of the blast furnaces in the Cleveland district he had himself had an opportunity of becoming acquainted; and in reference to the semi-closed plan of furnace top, for taking off a portion of the gas from the furnace throat, as used at the Thornaby furnaces, the construction of top in this case was similar to that in use at Messrs. Schneider's furnaces near Ulverstone; but although at the Ulverstone furnaces it had been found to work so successfully that the same plan was being adopted for more furnaces at the same works, in the particular instance of the Thornaby furnaces it had not been found to answer. The centre tube or brick chimney for taking off the gas was carried upon six arches springing from the inside of the furnace throat, and the charging of the materials into the furnaces was done through the spaces left between the arches; and the reason of the failure of the plan at the Thornaby furnaces was that constant trouble was occasioned by the damage done to these arches in charging, owing to the large size of the material in the charges. The Cleveland ironstone was raised from the mines and supplied to the furnaces in very large pieces, and would not pay for being broken to a smaller size, on account of its friable nature, and the quantity of waste that would be made in breaking it up; and in charging the furnace with these large pieces, they broke down the arches carrying the centre tube, so that this plan had now been abandoned at the Thornaby furnaces, and they were about to have closed tops put on, of the usual construction, for taking off the whole of the gas.

Independently, however, of the trouble arising with the arches in the semi-closed plan of furnace top, it was also found at the Thornaby furnaces that the portion of the gas so taken off was not sufficient in quantity for the purposes of raising steam at the works and heating the blast, even without attempting to use any of the gas for calcining the iron. In the discussion of this subject at the Liverpool meeting, he had urged the desirability of taking off the whole of the gas from a furnace, on account of the large additional heating power then at command; and this view appeared to be confirmed by the experience in the present instance at Thornaby, and by the statement given in the paper just read, that at some of the Cleveland furnaces where the top

was entirely closed, the gas was likely to be employed for calcining the ironstone in addition to heating the steam boilers and the hot-blast stoves.

The President inquired what was the effect of the increased size of the Cleveland blast furnaces upon the quality of the iron made.

Mr. D. Adamson understood that in the larger furnaces, foundry iron was made with rather less trouble than in the smaller ones, and with considerable less fuel, according to the statement in the paper. The charge was thus lighter, and the iron was made at less cost in the larger furnaces, which was attributed in the paper to the greater length of time that the materials remained in the larger furnaces.

The President asked what size of blowing engine was used for the large furnace at the Acklam Iron Works.

Mr. D. Adamson was not aware what size of engine was used at the Acklam furnaces, but the majority of the Cleveland furnaces were supplied with blast by a number of small blowing engines, and the rest by a single large engine. With regard to the pressure of the blast, he believed 3 lbs. per square inch, or rather less, was usually about the pressure at the engine in the Cleveland district, but he doubted whether the full pressure of the blast was always obtained in the furnaces, as it had been found by applying gauges on the tuyeres at the Thornaby furnaces, that the pressure at that point was considerably below what it was at the engine. At the Norton furnaces of Messrs. Warners, near Stockton-on-Tees, the pressure originally employed of $3\frac{1}{2}$ lbs. per square inch had now been reduced to only $\frac{1}{2}$ lb. per square inch; and he understood the lighter blast was preferred at those furnaces, and that a greater quantity of foundry iron was made than with a heavier pressure of blast.

The President inquired what was the usual number of tuyeres in the Cleveland furnaces.

Mr. D. Adamson replied that from three to six tuyeres were usually employed. At the Norton furnaces three large tuyeres were now used with the light blast, instead of six smaller tuyeres employed previously with the heavier blast; and from the reduction in the pressure of the blast, much less engine power was now required in blowing the furnaces for the same make of iron. At another furnace, however, in the neighborhood, the engines had been kept loaded to $2\frac{3}{4}$ lbs. per square inch pressure, while the pressure of the blast was reduced by throttling its passage through the main by means of a stop valve; and in that instance, consequently, the full benefit of saving in engine power by working with a lighter blast had not been realized.

Mr. G. Thomson observed that the size of the blast furnace was a very important subject to iron makers, and one upon which experience differed a good deal; and it was therefore highly desirable to get all the information possible, in order to make a fair comparison between different sizes of furnace. One point to be inquired into was the relative quantity of iron produced and of blast supplied in the large and small furnaces. In the large furnaces, 60 feet high, and 20 feet diameter boshes, making 300 tons of iron per week, the quantity of

blast had been stated in the paper to be 8000 cubic feet per minute; and he inquired what was the quantity of blast supplied to the smaller furnaces, 50 feet high, and 14 feet diameter of boshes, making 200 tons of iron per week.

Mr. Neil Robson did not know the quantity of blast supplied in the smaller Cleveland furnaces, but in the blast furnaces of the Glasgow district the quantity of blast supplied to a furnace about 50 feet high and 16 feet diameter of boshes, was usually supposed to be about 6000 cubic feet per minute.

Mr. C. Cochrane thought the 8000 cubic feet of blast per minute, which had been stated to be the supply to the large Cleveland furnaces, must be the theoretical quantity measured by the total displacement at the blast engine, without any allowance being made for escape between the piston and the cylinder and for leakages in the blast main; for the quantity of coke consumed in the furnace—26 cwt. per ton of iron made—would not require, he thought, more than 6000 to 6300 cubic feet of blast per minute, and he could not understand, therefore, so much as 8000 cubic feet per minute being supplied to the furnace.

Mr. G. Thomson remarked that 6000 cubic feet of blast per minute would be a maximum quantity in Staffordshire, and there were many furnaces of a smaller size in that district in which a much smaller quantity of blast was supplied.

Another point upon which further information was required in connexion with the Cleveland blast furnaces was the temperature of the blast in the large and small furnaces, and whether the large furnaces had been worked with the lower temperature of blast used in the smaller ones. It appeared from the paper that the blast for the larger furnaces was heated to 800° Fahr., while in the smaller furnaces the temperature had not been carried beyond 600°; and in order that a fair comparison might be arrived at between the different sizes of furnace, he should be glad to know the result of working the larger furnaces at the lower temperature of 600°, the same as the small furnaces, since the conditions of working should be made as nearly as possible the same in the different furnaces. The actual temperature of the blast, he believed, was generally much higher than was indicated by the ordinary rough test of holding a strip of lead in the blast to be melted by the heat; since, in order to melt the lead at all under such circumstances, the temperature of the blast must be considerably above the melting point of the metal, and the real temperature was, therefore, not ascertained with any approach to accuracy by the plan of melting metals in the blast. He inquired how the heat of the blast was ascertained when it was much above the melting point of lead, and whether any pyrometer was employed for showing the temperature accurately.

Mr. C. Cochrane replied, that for temperatures above that indicated by the melting of lead in the blast, a strip of zinc was used as the test instead of lead, and by that means a temperature as high as about 850° was indicated, the melting point of zinc being 770° Fahr.; for the actual temperature of the blast, when hot enough to melt either lead

or zinc, was found to be as much as 80° or 90° above the melting point of the metal. This was ascertained to be the case, as a general rule, whatever the melting point of the metal employed, as was shown by the aid of the improved pyrometer constructed on the principle of measuring the temperature of a copper ball heated in the blast by immersing it in a vessel of water, which afforded the means of measuring with the greatest accuracy the highest temperatures that were likely to be met with in practice.

Mr. E. A. Cowper explained that the pyrometer referred to was an improved arrangement of that invented by Mr. John Wilson, and described at a former meeting of the institution, and was a very simple and accurate contrivance for measuring high temperature. It consisted of a copper vessel holding exactly a pint of water, and a small cylindrical piece of copper made of such a size that its total capacity for heat should be 1-50th that of the pint of water; this copper piece was held for a sufficient time in the current of heated blast until it had acquired the full temperature of the blast, and it was then dropped into the vessel of water, when each 50° that the temperature of the copper had been raised produced a rise of 1° in the temperature of the water; and thus the real temperature was at once read off from a thermometer inserted into the water, having a properly divided scale showing 50° for each 1° of the ordinary scale. It was by this means that it had been ascertained that, when the heat of the blast was tested by a stick of metal being just melted on exposure to the current, the actual heat of the blast was about 70° to 90° Fahr. above the melting point of the metal. Thus, if lead melting at 620° were just melted by the blast, the heat of the blast might be taken to be about 690° ; zinc melted at 770° , and would show about 840° ; the antimony did not melt at less than 830° , and its melting would, therefore, indicate about 900° . Of course, if the stick of metal were melted quickly in the blast, it showed that the temperature was much higher than the melting point of the metal; and ordinarily the sticks of antimony of about 5-16ths inch diameter became fused in three or four seconds by exposure to the heated blast from the regenerated hot-blast stoves.

Mr. Neil Robson observed there could be no doubt as to the importance of the question of the height of blast furnaces; and it appeared from the paper a height of 70 feet had now been reached in the Cleveland district, while in the neighborhood of Glasgow, the highest furnace was only 55 feet, and generally the furnaces were not more than 42 feet high. At the Ardeer Iron Works, in Ayrshire, where there were four furnaces, each 52 feet high and 16 feet diameter at the boshes, the regular make of iron was 1000 tons per week, or an average of 250 tons per week from each furnace. Occasionally, one or two of the furnaces would make 270 tons per week, while the others might make less than 250 tons at the same time; but 1000 tons per week was the regular average make throughout the year, taking all four together. The highest make in the Cleveland district was stated at about 300 tons per week, with 60 feet height and 20 feet diameter of boshes; but, in comparison with the Scotch furnaces, the make of the larger Cleve-

land furnaces ought to be as much as 400 tons per week for the size of furnace used. The temperature of blast employed was in both cases from 800° to 900° , and the pressure about 3 lbs. per square inch. Hence, he thought, the cause of the smaller produce of the large Cleveland furnaces was to be sought in the materials that had to be worked, the nature of the ironstone to be smelted, and the quality of the fuel to be used. In the Ardeer furnaces the ore employed was, in a great measure, the blackband ironstone, and the fuel was raw coal; and he presumed these must be easier smelted than the materials in the Cleveland district, since the Scotch furnaces, though so much smaller, produced nearly as much iron in the same time.

Proc. Mech. Eng. Soc.

To Preserve the Plasticity of Clay.

The suggestion has been made to mix clay into glycerine in place of water for the purpose of keeping it in a plastic state for modeling or as a lute in chemical apparatus. To do this effectually, the clay must be first thoroughly dried and finely powdered, then mixed with glycerine of specific gravity, 1.231; clay thus prepared preserves its plasticity indefinitely. But if, on the other hand, the glycerine is added to the clay while still moist, or if the glycerine itself contain water, an evaporation is established and the clay becomes dry and hard as usual. To render the clay proper for modeling is said to require one-third of its weight of glycerine,—which is a large first outlay, but may be found economical, since it retains its properties indefinitely and requires no farther preparation.

Preparation of Oxygen By R. W. ARTLETT

From the London British Journal of Photography, September, 1865.

Having experimented on the valuable process for obtaining oxygen by the action of peroxide of cobalt on solution of hypochlorite of lime, with the view, among other things, of ascertaining what other substances might be possessed of the curious powers of the peroxide of cobalt, I have found that moist peroxide of iron or oxide of copper will answer the purpose. These substances, in the repeated trials I have made, have caused the evolution of a volume of oxygen equal to that obtained by means of the oxide of cobalt, and, like it, they lose none of their efficiency by use. The only difference I have observed is that, perhaps, the oxide of iron requires rather the highest heat to cause an equally rapid disengagement of gas. The oxide of copper answers perfectly, and if the oxide be not at hand, a few drops of nitrate of copper may be added to the hypochlorite of lime solution, and the gas will be given off abundantly immediately on the application of heat.

I have also tried peroxide of manganese, but have not yet sufficiently investigated its action. I may, however, state that it does not ac-

comply the end in view so well as the other substances. The quantity of oxygen liberated is smaller, and permanganic acid is formed.

Dalton's Thermometer.

From the London Chemical News, No. 279.

At a recent meeting of the Manchester Literary and Philosophical Society, Mr. Baxendell stated that the Society had in its possession a thermometer, constructed by the late Dr. Dalton, and which, it is believed, was used by him in many of his meteorological observations. The scale had the initials "J. D." and the year "1823" engraved upon it; and the freezing and boiling points of water are indicated on the stem by fine file marks. As it is known that the zero points of thermometers sometimes change to the extent of one or even two degrees in the course of several years, it occurred to Mr. Baxendell that it would be interesting to ascertain whether any change had taken place in this thermometer, and he had, therefore, lately tested very carefully the position of the freezing point, but found that no sensible alteration had taken place; and he believed, therefore, that great confidence might be placed in the observations which Dalton had made with this instrument.

Artificial Stone.

From the London Mechanics' Magazine, September, 1865.

To obtain a factitious stone which may take the place of the ordinary Turkey, Water of Ayre, and Arkansas stones used for sharpening cutting tools, and for kindred purposes, is the object of an invention recently patented by Mr. E. Parnacott, of Leeds. To this end he prepares a compound which will admit of being moulded to any required form, and which, when moulded may be hardened and brought to the consistency of stone. In carrying out the improved manufacture, the chips and dust obtained in preparing lithographic stones are reduced to fine granules, emery powder, borax, and saltpetre are added, and the whole thoroughly mixed in a mill. The mixture thus obtained is moulded to any required shape—for example, cutting and polishing tools; the same is first submitted to hydraulic pressure, and then to furnace heat, whereby the hardness and consistency of stone is imparted to the moulded articles. The following proportions will produce a good result, viz: pounded lithographic stone twelve ounces, borax two ounces, saltpetre half an ounce, and very fine emery two ounces. Place these substances together in an ordinary incorporating mill with edge runners, (such as is used for preparing mastic and sand,) the pan of the mill being heated by steam or gas, and subject the substances to the action of the mill until they are well mixed and incorporated. Then remove the compound thus formed and place it in strong iron moulds for the purpose of being submitted to pressure. These moulds are made of various shapes to suit the purposes for which the artificial stone is to be used.

The pressure necessary to effect a proper consolidation of the compound may be conveniently given by means of a strong hydraulic press. The amount of pressure which has proved satisfactory is about twenty tons per square inch of surface of the moulded article. When the requisite mechanical consolidation of the moulded article has been thus obtained, the moulded article is subjected to a white heat in any suitable construction of furnace, or to such a heat as will serve to fuse the borax and saltpetre, and effect the binding together of the granules of stone and emery. The time required for attaining this object will in general be from half an hour to one hour. To prevent the warping and running of the moulded compound under heat, it is clamped in moulds made of plumbago, fire-clay, or other like heat-resisting material, before being placed in the furnace. When it is required to produce cutting or polishing wheels, hones, or other like articles with a less cutting power than those made from the before-named mixture, ordinary chalk is substituted for a portion of the lithographic stone granules. The proportions of the chalk and the granules should be half of each to produce a good result, the proportions of the other materials being retained.

On the Effect of Blowing Blast Furnaces with Blast of very High Temperature. By Mr. E. A. COWPER.

From the London Artizan, November, 1865.

It is not proposed to detain the meeting with a history of the numerous attempts which have been made to raise the blast furnaces to a very high temperature, nor will the author occupy much time in the description of the means by which the desired result has been obtained, as a full account of the apparatus was given at the meeting of this Association held at Oxford, (though the paper on the subject was not printed in the Transactions.) In 1861, experimental stoves only on the new plan had been erected, and worked for heating the blast for one tuyere, out of the five used for one blast furnace. Such satisfactory results were however obtained, that it was clear that the difficulty of procuring blast of very high temperature had been overcome, and Messrs. Cochrane & Co., of Woodside Iron Works, Dudley, and Ormesley Iron Works, near Middlesbro'-on-Tees, forthwith erected large stoves on the new plan for a complete blast furnace; and it is now proposed, with your permission, to lay before the section the results obtained during upwards of six years practical working with these stoves. The effect of heating air on the new plan was that a temperature of blast of 1150° Fahr. was obtained, instead of only 600 or 700° , as with cast iron pipes in the common stoves. There was no loss of blast from leakage, owing to the cracked or damaged cast iron pipes; the iron produced was of rather better quality; 20 per cent. more iron was made from the same furnace; and fully 5 cwt. of coke was saved in the blast furnace per ton of iron made. The details of the construction of the new stoves will be easily understood.

First, there are two stoves, which are heated alternately, and used alternately in heating the cold air; these are filled with brickwork, "set open," (or small spaces between the bricks,) and from "regenerators" on the principle of Mr. Siemens' regenerator furnaces as now so largely and successfully used in glass houses, gas works, iron works, &c., both for obtaining great heat and economizing fuel. The outsides of the stoves are of thin wrought iron plate, lined with fire brick, the iron skin being necessary to retain the blast under pressure, whilst the fire brick resists the heat. Second, there are provided for the purpose of heating the stoves, valves for the admission of gas and of air into a central flue, where combustion takes place when a stove is being heated, the products of combustion passing up the flue and down through the mass of fire bricks forming the regenerator, and escaping at the bottom to the chimney, after the whole of the heat has been abstracted by the fire bricks, the temperature of the chimney being from 212° to 250° , or thereabouts, during the time a stove is being heated, viz: for a period of four hours. Then when a stove is hot, the gas and air are turned off, the chimney valve shut, and the cold blast is turned on at the bottom of the regenerator, and passes up through the bottom courses of brickwork in the regenerator, this very quickly becoming heated, and passing in this heated state up through the remaining courses of hot brickwork, and down the central flue through the hot blast valve to the blast furnace, the process of absorption of heat by the air being so perfect that as long as a few of the top courses of brickwork remain hot, the blast is well heated, the variation in the temperature of the blast being 100° Fahr., with four hours changes. Thirdly, the gas for heating the stoves was supplied from gas producers, similar to those commonly used by Mr. Siemens for his regenerator furnaces and which have been already described before the Association. They consist of a simple brick enclosure, or fire-place, with bars near the bottom for the admission of a very small quantity of air. The gas is formed by the slow combustion of a very thick fire, supplied with poor coal or slack, down a slope or hopper, the gas passing off from above the fuel through pipes to the hot blast stoves. Gas may, however, be taken from the top of the blast furnace for heating the stoves, provided proper arrangements are made to separate it from the dust which comes over from the blast furnace with it; and judging from recent practical experiments, it is certain that there are several ways in which this may be done with perfect success. The late Mr. James Beaumont Neilson, who did so very much for the iron manufacture by his original invention of the hot blast in 1829, was sufficiently long-sighted to predict the advantages that would flow from the use of blast of very high temperature, though, as it happened, he was limited to what could be obtained from passing the air through iron pipes exposed to a fire, as in common stoves. Mr. Neilson said, "In the new generator ovens that had just been described, the great capacity of fire brick for heat had been well taken advantage of, and a very important step in advance had been made by giving the means of raising the temperature of blast much above the extreme limit prac-

ticable with the old ovens; and he considered this would be productive of the greatest benefit in the working of the blast furnace—he had no doubt the ‘make’ of iron would be considerably increased by the higher temperature of blast given by the regenerative ovens. These anticipations have been fully borne out in practice during upwards of four years regular working of the stoves. The high temperature of the blast produces such an improved effect in the furnace, that the ‘burden’ is increased so as to save fully 5 cwt. of coke per ton of iron made; and as there is less fuel supplied, so there are less impurities taken in, and the quality of the iron is improved, the tuyere breasts do not work hot or burn, or give more trouble than usual, as the burden is increased as just stated. The same furnace is of course enabled to do more work, the ‘make’ being increased fully one-fifth, so that a given plant produces 20 per cent. more iron per annum, besides saving nearly three shilling per ton for coke. There is less friction or loss of pressure of blast in these stoves than in common ones; and there is no loss of leakage through cracked or burnt cast iron pipes or joints. More stoves are now being erected on the same plan.”

Mr. Siemens said that the application of regenerators which Mr. Cowper had brought before the meeting was one of the most interesting which could have been made. He had provided the means of heating blast really up to the temperature at which bricks would melt. Mr. Siemens defined the chemical process effected by Mr. Cowper’s arrangement, and affirmed that there was no deterioration of the quality of the iron produced by that process. After other remarks, Mr. Cowper was thanked for his paper.

Proc. Brit. Association.

Gases Dissolved in Cast Iron.

M. Cailletet has communicated to the Academy of Sciences at Paris, a series of experiments upon the nature of the gases dissolved in cast iron. The result in two cases of iron of very different composition, was as follows :

	English grey-cast. Made with coke.	Feebly grey. Made with charcoal.
Hydrogen,	33.70	38.60
Oxide of carbon,	57.90	49.20
Nitrogen,	8.49	12.20
	100.00	100.00

M. Cailletet could not satisfy himself whether the nitrogen was or was not derived from a little atmospheric air hanging about the apparatus, nor could he succeed in making any satisfactory determinations on the gases dissolved in melted steel.

Extract from the Monthly Report of the Engineer of the Manchester Association for the prevention of Boiler Explosions.—July 4, 1865.

From the London Artizan, August, 1865.

Explosion No. 27, which was of a very disastrous character, two persons being killed and seven others injured, occurred at a brewery on June 1, to a boiler not under the inspection of this Association. I made a personal investigation a day or two after the explosion had occurred, and found that it arose simply from collapse of the furnace flue, a subject to which this Association has called such constant attention in its reports.

The boiler was of ordinary Cornish construction, having a single furnace flue, internally fired. It was 32 feet long, 7 feet in diameter in the shell, and 4 feet in the internal furnace and flue tube, which was $\frac{7}{8}$ of an inch thick, while the safety valves were loaded to a pressure of 50 lbs. and upwards.

The flue tube collapsed from one end to the other, rending at the angle iron at the back of the shell, as well as at some of the other ring seams of rivets. The boiler was moved forward away from the chimney for several feet, and the greater part of its setting torn down, while the rush of water from the furnace end carried away a considerable portion of the engine house wall, and scalded the workmen near the boiler.

The explosion was attributed, as usual, by general report, to shortness of water, but examination of the plates showed no evidence of overheating. There could be no doubt that the explosion resulted entirely from the weakness of the flue, which was insufficient for any pressure above 30 lbs., but could have been made perfectly safe at 60 lbs., or even at a much higher pressure, by the introduction of flanged seams, or encircling hoops of T-iron, or bridge rail section, applied at the ring seams of rivets. There are also other means for strengthening furnace flues, such as water pockets, or water tubes, &c.; but since these strengthening pockets or water tubes cannot extend into the furnace, it is well to supplement them at that part with flanged seams or T-iron hoops. After boilers are completed and set to work, the furnace tubes can readily be strengthened with angle iron hoops made in segments so as to be passed into the boiler through the man-hole, and fixed to the tube when in place. Full particulars of this method of strengthening furnace tubes were given in the report for June, 1862, and a considerable number of boilers under the inspection of this Association have been strengthened in this way.

It seems difficult to understand how any maker could have constructed a boiler within the last few years without adopting any one of the simple means to provide against collapse which have just been enumerated above and are now so generally known. The explosion clearly shows the importance of an independent system of periodical inspection for boilers of even first-class firms, where they suppose themselves to be perfectly free from danger; and had the boiler in

question been under the charge of this Association, not a day would have been lost in apprising its owners of the dangerous position they were in.

The jury found that the deceased met with their deaths from the accidental bursting of the boiler, adding that they considered that the furnace flue had not been of sufficient strength for the pressure.

Accidents from Steam Machinery.

From the London Journal of the Society of Arts, October, 1865.

In consequence of the removal of certain restrictions respecting the employment of steam power in manufacture, the *Moniteur* has collected and published an account of the accidents which happened through the use of steam during the past year. It appears that the accidents were only sixteen in number, but that the number of persons who were killed, or died afterwards of the injuries inflicted, amounted to forty, and that fifteen other persons were wounded more or less seriously. Of the sixteen accidents, four occurred in sugar works, three in paper manufactories, two each in distillery and drug works, and one each in other industries. The causes of accident are classified as follows: Eight occurred by the explosion of cylindrical boilers, three by that of tubular boilers with interior furnaces, one by the explosion of a locomotive, and four by that of steam heating apparatus. The immediate causes are supposed in eight cases to have been the bad quality of the metal employed, or the vicious arrangement of the furnaces; in seven others, carelessness or want of superintendence on the part of engineers or stokers, and in the remaining case from the imprudence of other persons. The *Moniteur* gives the details in each case, in order that manufacturers may take warning for the future. This return, of course, does not include railway or other accidents which occurred in connexion with, but were not immediately caused by steam machinery.

Effluvia from Sewers.

From the London Mechanics' Magazine, September, 1865.

The effluvia which escape from sewers, in the very attempt to ventilate them, are of a very pernicious character, and have often been productive of mischievous effects. M. Robinet, a French chemist, has devised a very effective means of freeing the sewers from them. His plan has already been carried out on a small scale. He proposes that the furnaces of factories shall derive their supply of air from the sewers; the latter will thus be emptied of their mephitic gases, which will be destroyed by combustion, fresh air from the atmosphere supplying their place. He calculates that if the combustion of only 70,000 tons of coal can be thus economized annually in Paris, or only a tenth part of what is burned there, the sewers will be supplied with about 140,000,000 cubic feet of fresh air—that is, more than seven times their contents—daily.

*On the Fracture of Polished Glass Surfaces.** By F. H. WENHAM.

From the London Mechanics' Magazine, October, 1865.

The short communication which I submit to your notice scarcely merits consideration as a discovery; but as the microscope has in this case immediately detected the cause of a well known phenomenon, I bring it forward as an example of the use of the instrument in practical investigations. It is a fact known to the philosophical instrument makers, that if a metal wire be drawn through a glass tube, a few hours afterwards the tube will burst into fragments. The annealed glass tubes used for the water gauges of steam boilers are sometimes destroyed in this way, after the act of forcing a piece of cotton waste through them with a wire for the purpose of cleaning the bore. This will not happen if a piece of soft wood is employed. The late Andrew Ross informed me that on one occasion, late in the evening, he lightly pushed a piece of cotton wool through a number of barometer tubes with a piece of cane, for the purpose of clearing out any particles of dust. The next morning he found most of the tubes broken up into small fragments, the hard siliceous coating of the cane proving as destructive as he had previously known a wire to be.

After having drawn the point of a steel burnisher over the surface of a slip of polished glass, the following appearances will be observed under the microscope, using the polarizing apparatus and selenite plate with a two-thirds object glass. A colored stripe is visible in the passage of the burnisher, showing that the surface of the glass has been placed in a state of tension in the direction of the line. The glass, too, seems not altogether devoid of plasticity, for the waves of color show that it has been carried forward in ripples, resembling the mark left on a leather bound book after the passage of a blunt point. It may be inferred from this that the mere burnishing of the surface of the glass with a substance inferior in hardness will, without any scratching, cause an irregular strain in the bore of tubes sufficient to split them, and the concussion attendant upon the fracture often reduces the tube to small fragments. If the burnished lines upon the glass slip be examined a few days afterwards, the colors will have become much less visible, showing that the strained portion of the glass partly recovers its equilibrium.

On attempting to polish out a minute scratch on the surface of a piece of glass, it sometimes appears to widen during the process, and at length resolves itself into two irregular parallel rows. Also, a clean cut made with a diamond on a piece of plate glass, if left for a time, the surface in the vicinity of the cut will break up, forming a coarse irregular line. If the diamond be raised and struck lightly on the surface of the glass, the form of the edges of the short stroke thus made may be plainly seen, using the binocular polariscope. A conical ridge of glass appears to be left with its apex under the line of the cut, and the glass is frequently wedged up on both sides of the ridge, explaining the cause of the double line of fracture which sometimes makes its appearance in polishing out a scratch. This effect may also

* Read before the Microscopical Society.

be exemplified by observing the marks left on a polished glass surface from the light blows of a steel centre punch. The point of the punch drives in an atom of the glass, and the fracture extends some distance into the interior, expanding downwards in the form of a truncated cone. The polariscope shows that the conical centre is in a state of compression, and that the surrounding exterior portion of the glass is also under strain. The smooth, round edge of a glazier's diamond, when drawn over a polished glass surface, burnishes down and compresses the glass beneath the cut, and in the case of thin sheets the wedge-like force of the compressed line splits the glass nearly through, but when the glass is thick and rigid, as plate glass, unless the sheet is bent back and broken through immediately after the cut, greater difficulty will be experienced if allowed to remain for a time, for the compressed line of glass will speedily tear up the portion on both sides, leaving a wide ragged groove in place of the original clean and scarcely visible line.

For the Journal of the Franklin Institute.

The Giffard Injector. By CHARLES E. EMERY, Asst. Eng. U.S.N.

The writer, by permission, recently tried some brief experiments with a view of ascertaining the cost of forcing water with a Giffard injector, an account of which may not be uninteresting, inasmuch as there is a wide difference of opinion in regard to the economy of using this device for feeding boilers. The injector employed was one of moderate size attached to the auxiliary boiler of the U. S. Steam Expansion Experiments. The water was supplied from a tank, with a head of from three to four feet, and was delivered by the injector into a pipe with two branches, one connected to the boiler, and the other to a water chamber, having attached to it a steam gauge and safety valve. Each branch of the pipe was provided with a stop valve, so that the water could at pleasure be forced into the boiler or out of the safety valve on the water chamber at the desired pressure shown by the gauge. Before starting an experiment, the boiler was supplied with sufficient water to last an hour without feeding, the boiler and water chamber gauges being compared by opening valves on both branches of lower pipe when the injector was in operation. The water connexion with boiler was then carefully closed. During the experiments the water was measured before being supplied to the injector; the safety valve on the water chamber was loaded to the desired pressure, and the injected water passed through it, and was again carefully measured, the increase in quantity showing the amount of steam drawn from the boiler. The "overflow" water was collected in a separate vessel and returned to the first tank. The following table shows the best results of the experiments under the conditions expressed. The pressures and temperatures are the means of records taken every fifteen minutes.

No.	Duration of Experiment.	Average Pressures.		Average Temperatures.		Water from tank.		Discharged water.		$b - a$	$b \div (b - a)$
		Boiler.	Water chamber	Water in tank.	Discharged water.						
Minutes.	Pounds.	Pounds.	Degrees F.	Degrees F.	Cubic ft.	Pounds.	Cubic ft.	Pounds.	Pounds.		
1	60	70	62.0	43.0	127	18.37	1146	20.01	1232	86	14.32
2	60	69	62.2	42.4	124	17.87	1115	19.25	1186	71	16.70
3	60	66	75.8	43.0	125	15.94	994	17.50	1078	84	12.83
4	30	61	40.0	44.0	112	9.13	570	9.88	611	41	14.90

In three of the above experiments the average pressure of steam exceeded that of the water. In No. 3 the water pressure was in excess, and it was found that it could be carried much higher without stopping the operation of the injector. In one instance, with seventy pounds of steam, by weighting the safety valve on water chamber, the water pressure was increased to one hundred and ten pounds, which caused a larger "overflow," and less water was delivered under pressure.

The above would seem to indicate that the injector forces, against pressure, sufficient water to condense the steam used. Two of the experiments fall short of this by calculation, due probably to the heating of the small quantity of "overflow" water. The better result of No. 2 over No. 1 was doubtless occasioned by the adjustment of the valves, a smaller quantity of water being delivered, but at a less comparative cost. Nos. 3 and 4 indicate that small changes in the relative pressures of steam and water have some little influence on the ratio.

Assuming as the best result that one pound of steam will force sixteen pounds of water against a pressure of sixty pounds, or one hundred and thirty-eight feet high, thus performing 2208 foot-pounds of work, and, bearing in mind that few steam engines use more than one pound of steam per horse power per minute, we find that the injector requires nearly fifteen times the quantity of steam used by a steam engine to do the same work, or a steam pump should force nearly fifteen times as much water as an injector, when using the *same* quantity of steam.

For feeding *cold* water to a boiler the injector is more economical, as it returns through the feed water all the heat it takes out in the steam, and the pump, though it requires less steam, wastes all the heat of what it does receive. When, however, the pump is used in connexion with a condensing engine or heater, so that the temperature of the feed water is raised to upwards of one hundred degrees, there can be no question of its superior economy, as it will convey to the boiler, by means of the feed water, a greater number of units of heat from the exhaust steam of the main engine than will be required for the steam to drive the pump itself.

The value of an injector, as simply an auxiliary feed to a steam boiler when the engines are stopped, cannot be doubted, but for constant use as a boiler feed, under ordinary circumstances, the force pump would seem to be preferable, and that can be most economically operated by the main engine, for the cost of the power in a small engine is proportionately much greater than in a large one—a point apparently ignored in these days of independent feed, air, and circulating pumps.

Alloying of Iron and Steel with Tungsten.

From the London Mechanics' Magazine, September, 1865.

There has been considerable controversy from time to time as to the effect which is produced upon iron and steel by alloying them with

small portions of tungsten. "Tungsten steel," especially excited much attention some seven or eight years ago. It was first produced in some Austrian steel works, and at first, says Dr. Hoffman, "appeared so successful as to threaten a complete revolution in the working of cast steel." Never before, according to the partisans of the new alloy, had steel been produced of such tenacity and hardness. They declared that ordinary cast steel of best quality, hardened by the usual means, could be turned and bored by tools of tungsten steel. They cited analyses to show that the swords of Damascus, so celebrated for their hardness and elasticity, contained traces of tungsten, and to these they attributed the fine qualities of those weapons. They alleged that the new steel cost less than the best English cast steel, and lasted four times as long. Every where patents were taken out for alloys of steel and tungsten, in this country Mr. Mushet alone obtaining nine in one year. Tungsten steel seems, nevertheless, to have been a delusion. Many eminent metallurgists, among them Dr. Percy, Mr. E. F. Sanderson, of Sheffield, and Professor Tunner, of Leoben, declined to believe in it from the first, and nobody believes in it now. There seems ground, however, for the idea that the addition of tungsten to cast iron improves its quality. A recent number of the *Annales de Chimie* contains an account of numerous experiments which have lately been made by M. le Gruen at the Marine Foundry at Nevers, which appear to prove pretty conclusively that cast iron has its tenacity increased by about one sixth by the addition to it of about two per cent. of tungsten. The tungsten was added, of course, as wolfram, metallic tungsten not having hitherto been available.

On Chain-testing Machines. By SIR W. G. ARMSTRONG, C. B.

From the London Journal of the Society of Arts, No. 730.

The engineering firm of which I am a member having been entrusted with the construction of the apparatus for testing chain cables and anchors, lately established at Birkenhead by the Mersey Harbor Trustees, had occasion to enter into a very careful consideration of the conditions requisite for effecting the operation in the best possible manner. As public attention has been forcibly directed of late to the importance of more accurate methods of testing chains and anchors, a few observations on the subject of the Birkenhead machine will not at the present moment be mistimed.

The most important consideration in the construction of a chain-testing machine is to obtain an accurate indication of the strain upon the chain. The hydraulic press has been for many years the appliance usually employed for exerting the strain, and nothing can be better fitted for the purpose; but the methods of determining the amount of the strain have been extremely imperfect. Most commonly the strain has been estimated by the indications of a mitred valve pressed down by a lever and weight. The impossibility, however, of

restricting the tightening surface of the valve to a definite annular line, so as to exclude any variation of area, rendered this mode of indication highly delusive; so much so, indeed, that the attendants generally paid more regard to the indication afforded by the crackling of the scale on the surface of the iron than to the amount of load upon the valve. By substituting a loaded plunger for a loaded valve, the uncertainty arising from variability of surface is obviated, but a plunger requires a packing to make it water-tight, and the effect of the friction of this packing has to be considered in relation to the friction of the press. A plunger without friction would give untrue indications of the strain, unless the press were also without friction; but friction cannot be avoided in the press, and therefore friction becomes a necessary element of accuracy in an indicating plunger. To make this more apparent it is only necessary to consider that in the press the friction of the packing lessens the tension exerted on the chain, while in the case of the indicator the friction of the packing lessens the weight necessary to indicate the pressure. If, therefore, these two frictions be in harmony, the load on the indicator will be diminished in the same proportion as the tension on the chain, and thus a direct indication of the strain upon the chain will be obtained.

The proper and usual packing for the hydraulic press is a cupped leather, but as the lip of the leather is pressed against the surface of the ram by the action of the water, the amount of its friction varies directly as the pressure. It is therefore necessary that the indicating plunger should also be packed with a cupped leather, in order that its friction may likewise vary directly as the pressure. But as the ratio of circumference to area is very much greater in the small ram of the indicator than in the large ram of the press, it is obvious that with similar leathers the relative friction would be widely different in the two cases. The friction may, however, be brought to a proper adjustment by reducing the breadth of the lip in the leather of the indicator until its friction is in unison with that of the press leather. This adjustment should be made when the press ram and the indicator plunger are both perfectly clean and free from any lubricating substance, and in no subsequent use of the machine should either oil or grease be applied to these parts. The effect of employing a lubricator is to diminish the friction in the first instance, but afterwards to increase it, because the unctuous character of the lubricant is soon exchanged for a stickiness which produces an opposite effect. In fact, when grease or oil is used the frictions become so irregular as to render impossible an accurate correspondence between the press and the indicator.

There is another desideratum in the testing of chains which requires a further elaboration of the indicating apparatus. When a chain breaks in the test it is desirable to show, not only that it failed to bear the full test strain, but also what was the amount of the strain exerted at the moment of fracture. In the case of the Birkenhead machine, various indicators, upon the principle of those commonly used for steam pressure, were tried for the purpose of effecting this latter object, but none of them gave satisfactory results. An apparatus was therefore

designed for the object, which has since come into very general use, under the name of the "pendulum indicator." In this apparatus the pressure upon the indicating plunger is exhibited by the travel of a pendulum through a graduated arc. The movement is communicated from the plunger to the pendulum through the medium of a compound lever. When a chain breaks the pendulum falls back until stopped by a ratchet, but leaves a marker at the exact point on the scale attained by the pendulum at the point of rupture.

I have hitherto spoken of friction only in reference to the packing of the apparatus. This friction, as I have already stated, varies with the pressure, but there is also the constant friction due to the weight of the moving parts to consider. If the machine be used exclusively for high strains in relation to its weight, this constant friction will be unimportant, but if a heavy machine be used for testing light chains, a considerable element of error will be introduced, unless a proportionate friction of the same constant character be added to the indicator. Still, however, it is better that very heavy machines should not be used for testing very light chains, unless they be constructed with more than one press, to act separately for light chains and conjointly for heavy chains. With this view the Birkenhead machine has three presses, the centre one being used alone for light strains, and the three acting in concert when great strains are to be exerted.

Although an hydraulic indicator, properly constructed and correctly adjusted in regard to its friction, may be safely relied upon as indicating with sufficient precision the strain exercised by the machine, yet, for the purpose of ascertaining in the first instance when correct adjustment has been attained, and also for detecting any discrepancy which may subsequently arise from dirt upon the ram or plunger, or from any other cause producing irregular friction, it is necessary that every machine should be provided with a lever indicator, to which the strain may be immediately applied, and the strain ascertained by the lifting of a weight. Such an apparatus requires to be accurately fitted with knife-edge bearings, in order to afford delicate indications, but as these are liable to deterioration by too frequent use, it is better to reserve the lever apparatus as a standard of reference for adjusting the hydraulic indicator, which is not liable to deterioration by use. It is not necessary that the lever indicator should range as high as the hydraulic indicator; for if the two indicators register alike through a sufficient series of the lower strains, no discrepancy would be manifested if the comparison were carried to the highest powers of the machine.

I may here mention that nothing so soon deteriorates the lever apparatus as inadequate length of the knife-edges in relation to the strain upon them. The conclusion arrived at in the Elswick Works is, that not less than one inch length of edge should be allowed to every five tons of strain upon the bearing.

In the arrangement of a public chain-testing establishment, it is desirable that the apparatus for the various operations should be placed in such succession as will allow the chains to move from pro-

cess to process without any retrogression. The Birkenhead Chain-testing Establishment commences with a store room for the reception of unproved chains. From this store each chain is dragged by a steam power capstan through an opening in the partition wall on to the testing bench of the machine. It is there made fast, at the one end to the press and at the other to the cross-head, supported on live rollers, which cross-head may either abut against a stop or be connected with the lever indicator. After the chain has been proved it is dragged by a second capstan directly forward in the same line into the examining room, and there stretched upon one of the benches, where it undergoes a close inspection. If found perfect it is then hauled forward by a third capstan through the heating oven and blocking trough, and is thence passed complete into the delivery store at the opposite end of the establishment. The course of the chain being thus in one straight line, it is necessary to carry it over the machinery at each end of the testing bench, and to accomplish this a channel of wrought iron is fixed over the machinery to support the chain in its passage. Should the chain fail in the test, or be found defective on examination, it is drawn off by one of the capstans to the smiths' fires, placed on the floor of the examining room, and after repair is again hauled to the testing bench for a second proof. For the convenience of handling heavy chains at the smiths' fires, a hydraulic crane is connected with each fire. Between the testing and examining rooms there is an intermediate room, called the indicator room, in which the lever and hydraulic indicators are placed, and the valves of the apparatus manipulated by an attendant in view of the indicators.

Anchors are received into the same store room as the chains, and the usual appliances are provided for fixing them in the test. Overhead cranes are employed for lifting the anchors as well as for lifting the chains in the two stores.

There are two testing machines in the establishment, fixed at opposite sides of the room. These are similarly arranged in every respect, but one of them is adapted to test up to a strain of 200 tons and the other to 300 tons.

The hydraulic pressure is supplied from a neighboring accumulator, used for a system of hydraulic machinery, at work in the adjacent dock.

As the general practice is to make chain cable in lengths of fifteen fathoms, the Birkenhead machines are adapted for that length. The Board of Trade have recently fixed upon that length as the limit of length of chain to be tested at one time. The propriety of their so doing has been called in question, but I may state that it is the opinion of those persons who have the management of the Birkenhead machines, that no advantage of any kind would be gained by testing chains in greater lengths. If there is to be a limit it is clear that such limit is best fixed at the length at which chains are usually made. There is, besides, a positive objection to exceeding that limit, because a greater length than fifteen fathoms cannot be tested without the use of intermediate supports, which, whether they be slides or rollers, are objec-

tionable as being liable to produce variations of strain in different parts of the chain.

Another objection to permitting indefinite lengths of chain to be tested at one time arises out of the stretch to which chains are subjected in testing. This stretch occasionally amounts to five feet in fifteen fathoms, and if that length of chain were greatly exceeded, it would involve a press of very inconvenient length, or necessitate taking repeated holds of the chain, which would be highly objectionable. I think, therefore, that the Board of Trade have acted wisely in imposing a limit and in fixing that limit at fifteen fathoms.

Proc. Brit. Association.

Explosive Compound.

From the London Mechanics' Magazine, September, 1865.

In the *Mechanics' Magazine* for August 11 an account was given of some Swedish experiments with that highly explosive compound, nitro-glycerine, which Mr. Nobel, a Swedish engineer, is endeavoring to bring into use, instead of gunpowder, for blasting purposes. The same "blasting oil," as Mr. Nobel calls it, has since been experimented with in Cornwall, with very satisfactory results. It is an oily fluid, of a light yellow color, and of 1.6 specific gravity. It consists of three atoms of nitric acid, or 3N O^5 , combined with one atom of glycerine, or $\text{C}^6\text{H}^5\text{O}^3$, so that its ultimate composition may be represented by $\text{C}^6\text{H}^5\text{O}^{18}\text{N}$. It bears the temperature of boiling water without explosion or injury, but explodes at about 360° Fahr. The changes which occur during explosion, convert each volume of it into 469 volumes of carbonic acid, 554 volumes of steam, 39 volumes of oxygen, and 236 volumes of nitrogen, being a total of 1298 volumes of gas for each volume of the liquid oil. The gases produced by the explosion of gunpowder measure, when cold, only 250 times the bulk of the gunpowder exploded, so that, supposing the gases evolved to be in each case at the same temperature, nitro-glycerine would thus be five times more effective than its bulk of gunpowder. A great deal more heat, however, is generated by the explosion of nitro-glycerine than by the explosion of gunpowder, and the gases produced by the explosion of the former are therefore in so much higher a state of tension than those produced during the explosion of the latter that the new agent is really thirteen times more effective, bulk for bulk, and eight times more effective, weight for weight, than the old. The use of nitro-glycerine in blasting, therefore, enables thirteen times more disruptive force to be applied, by means of a hole of a given size, than can be brought to bear by means of a bore of the same dimensions when gunpowder is used, and one result of its substitution for gunpowder, for blasting purposes, is thus a very great economy of labor. When there are rents in the rock in which the bore is made, the advantage of nitro-glycerine over gunpowder is greater than thirteen to one, amounting, indeed, to between twenty and thirty to one, by reason of the explosion of nitro-glycerine being so much more rapid than

that of gunpowder that the force of its explosion is not appreciably diminished by fissures in the bore which would diminish the effective force of an explosion of gunpowder by fifty per cent. For the same reason, "tamping is never required, a shaft of loose sand being sufficient in all cases. Hence, accidents in charging are impossible, besides the saving in time." Other advantages of nitro-glycerine are that, "being insoluble, discharges under water, or in water-carrying rocks, may be effected by it without cartridges; and, as the blasting oil can only be exploded under certain conditions, and by means of igniters manufactured specially for the purpose, its storing and transport involve no danger." Curiously enough, contact with fire is not sufficient to ignite it at ordinary temperatures, neither is contact with phosphorus, or even with potassium. The chief danger in its use is from its intensely poisonous qualities, but these can be effectually guarded against without much trouble. At present, nitro-glycerine is more costly than gunpowder in about the proportion which it is more effective, so that, for charges of equal force, nitro-glycerine and gunpowder cost about the same. The saving of labor and time which results from the use of the former, however, renders it by far the more economical agent of the two.

On Surface Condensation. By OTTO DINGLER and FRANZ PFEIFFER,
Engineers to the Austrian Lloyds.

From the London Artizan, November, 1865.

Great differences of opinion exist as to the amount of saving in fuel to be derived in marine engines from condensation of steam on cold surfaces, as compared with that obtained by the injection of water. The theoretical gain which may be realized by feeding the boiler with distilled instead of salt water may be readily calculated, the balance in favor of distilled water being equal to the loss represented by the blowing off and scumming required when salt water is used.

The real loss of heat, however, is likely to exceed that found by this calculation, as in all probability a certain quantity of the steam generated will be carried away through the outlet pipe with the waste water, in consequence of the continual oscillations in the level of the water. These quantities, which are thus uselessly abstracted from the boiler, have not to our knowledge ever been measured, but such measurement may readily be made in the following manner:

Supposing the outlet pipe, instead of issuing overboard, to be led into a vessel containing x kilogrammes of water at a temperature t , this quantity will, after the lapse of a certain time, which may easily be measured, have increased to y kilogrammes and assumed a temperature t' . The quantity of heat contained in the original quantity of water was $= x \times t$, the quantity of heat contained in the y kilogrammes is $= y \times t'$ units of heat, therefore the increase representing the abstraction of heat from the boiler will be $y \times t' - x \times t$ units of heat. Now, supposing it had been ascertained by simultaneous direct mea-

surement that, during the same lapse of time z kilogrammes of water of a temperature t' had been let into the boiler, there will obviously remain

$$z - (y - x) = z + x - y \text{ kilogrammes}$$

that had been usefully employed and required for their evaporation

$$(z + x - y)(650 - t'')$$

so that the loss of heat involved by the blowing off will be represented by the expression

$$\frac{y t' - x t}{(z + x - y)(-t'')} \text{ units of heat.}$$

In order successfully to perform such an experiment, the following points should be kept in view: The vessel in question should be as large as possible, and the quantity of water (x) contained therein originally be of a temperature sufficiently low that the duration of the trial may not be too short, and the steam may be readily condensed. The vessel should be clothed with a non-conducting material, the inlet taking place from below, an aperture of sufficient size being provided for the escape of the air. On the other hand, the steam generated in the boiler and supplied to the engine, representing the quantity of heat usefully employed, should not be liable to priming, and this condition may be complied with, at least with an exactitude sufficient for practical purposes.

We have observed that a loss of heat is involved by a certain quantity of steam being carried off when the saline water is let out of the boiler. The question arises, in what proportion water and steam may be mixed together in this case, and though this question is immaterial from a mere practical, it is sufficiently interesting from a scientific point of view to justify its being inquired into. This may be done in one of two manners.

If we subtract from the measured *total* loss of heat, as above, the calculated loss that would take place if water only were abstracted from the boiler, the difference between these two will represent the quantity of heat uselessly abstracted from the boiler by the steam that has been carried off, and from this the weight of such steam may be readily deduced. Another method is as follows: Letters denoting the same as above, and supposing T to be the temperature in the boiler, n the quantity of water, and m the quantity of steam (in kilogrammes) abstracted from the boiler in the manner alluded to, it is obvious that

$$y t' - x t = n (T - t) + m (650 - t),$$

and as

$$n + m = y - x,$$

we find for the quantity of steam in question

$$m = \frac{y t' - 2 x t - y T + y t + \times T}{650 - T}.$$

The accurate carrying out of a series of experiments in the described manner would tend to do away with the prevailing differences of opin-

ion on the saving of fuel that may be realized by the use of distilled water in the feeding of boilers, and lead to a proper appreciation of this saving. The latter, however, is not the sole element acting in favor of surface condensation. The question also arises whether the durability of the boiler may not be affected by feeding it with a different kind of water. On this point, however, the most contradictory and peculiar opinions are met with. This much, however, seems certain, that boilers working with distilled water are liable to a far greater internal oxidation than those in which the deposits of salt prevent a direct contact between the metal and the salt water. The naval engineers of all countries are engaged at present in inquiring into the causes of this increased corrosion, and many controversies have arisen on this subject without having yielded as yet any result beyond the following four hypothetical explanations of the phenomena of oxidation observed in boilers working with surface condensers, viz :

1st. The sulphur contained in the vulcanized india rubber rings used for the packing of the condensation pipes is partly absorbed by the feed water and transmitted to the boiler itself, and the metal is stated to be affected by the corrosive action of such sulphur.

2d. In a manner similar to No. 1, copper derived from the condensation, feed, and steam pipes is supposed to be deposited on the sides of the boiler, where it would produce galvanic effects.

3d. Distilled water is stated to have the property of affecting iron in a higher degree than impure or common spring water.

4th. The greasy substances from the steam cylinders, pumps, &c., introduced into the boiler with the feed water, form acids which generate a decomposing action, which operates destructively on the boiler plate.

We need not enumerate all the *pros* and *cons* urged with reference to these hypotheses, but content ourselves with observing that the supporters of the two first-named suppositions, which are obviously the weakest of all, seem to attribute to the decillionth parts of a grain of sulphur or copper, a very powerful homœopathic action on the colossal masses of iron of the boiler. As regards the supposed action of distilled water, for which no scientific reason can be adduced, our own extended experience enables us to utterly deny it, and we request more particularly engineers engaged in the manufacture of sugar to ascertain with accuracy when a boiler, affected in the manner alluded to, has always been fed with *pure distilled* water, or if the water supplied to the boiler contained a *per centage of sugar*, derived from such apparatus as may have become leaky, as we notice that, in this quarter, the assertions of the injurious effect of distilled water have been chiefly urged and supported. We also have often met with boiler water as black as ink, but only in cases when foreign substances had found their way into the steam generator. On the other hand we certainly profess the opinion that acids produced by *greasy* substances do, indeed, act destructively on iron, and this view of ours as to the injurious effect of such acids, as well as carburetted hydrogen, is corroborated by the above-mentioned experience relating to feed water mixed

with sugar and syrup, and also by the fact, not generally known to engineers, that iron and steel are very injuriously acted upon by heavy liquid carburetted hydrogen substances.*

On the sides of boilers fed with distilled water, (and more particularly at the height where the level of the water changes, *i.e.* within the limits of the water level,) a deposit consisting of incrustation, grease, and some oxide of iron may be found, which preserves the boiler plate from the contact of the water, there being no adhesion between the water on this rough but very greasy mass. The flues also are covered with a similar deposit, less greasy in appearance, the existence of which alone should suffice to render questionable the destructive action of *pure* distilled water.

The high temperature of surfaces that are encircled by fire, prevented from contact with water by the deposit alluded to, and consequently very liable to incandescence, and the corresponding high temperature of the deposits themselves, are amply sufficient to decompose the greasy matter, by which the gas generated in the process of decomposition will tear up the incrustation, allowing the water a free access to the overheated iron. Though neither the small quantity of hydrogen gas generated thereby, nor the excessive instantaneous production of steam may be attended by any danger, still the partial oxidation of the boiler plate cannot be denied, and this process being repeated an infinite number of times, its consequences must become perceptible at length. It is obvious that the minor explosions that are repeatedly observed, as well as the noise that is audible at times, are easily accounted for by this phenomenon.

By the combustion of grease, however, several products, such as combustible oils, acids, &c., are generated, the action of which on metallic iron—though at present not yet sufficiently known—cannot be denied, as will appear from the above statements. The fact of the boiler plates being chiefly affected at the height of the level of the water, may be easily accounted for by the separation of portions of the deposit alluded to, effected by the fluctuations of the water, and subsequent action of the acids thus freed, upon the denuded metallic iron surface.†

From this it is clear that, to explain the speedy destruction of the boiler plates, a galvanic action, or a peculiar, not yet discovered, pro-

* During four years we have observed, at least once a week, that the iron and even steel valves and steel wire spiral springs of a force pump for gas were decomposed by such substances containing carburetted hydrogen, benzine, euphion, &c., as were separated from the gas at a pressure of from 25 to 30 atmospheres, and had to be let out of the pump every hour. The valves that were made of best English cast steel, after iron had proved inefficient, were corroded by this liquid, which gave them the look of raw Damascus steel, and the steel springs were unwound like raw cord. The gas in question was prepared out of distilled colophorium (so-called colophorium oil) and was free of all foreign substances.

† Some have tried to deny the pernicious action of acids of grease on boiler plates, urging that, by the introduction of alkalis into the boiler for the saponification of grease, the oxidation of iron could not be stopped; but by this they do not prove the non-existence of acids of grease, but merely that fuller's earth acts on iron in the same manner as non-saponized acids of grease.

perty of distilled water need not be resorted to, these hypotheses being as preposterous as the alleged formation of oxygen and hydrogen gas, and its ignition by a spark produced inside the boiler, (*sic.*) the dangerous increase of the pressure of steam by hydrogen gas accompanying it, and so forth.

The question arises, how to neutralize the injurious action of these acids of grease on the metal of the boiler? As we have observed previously the incrustations of salt preserve the plate from immediate contact, and consequently from the injurious action of the boiler water, or rather of those foreign substances contained therein. It would, therefore, be requisite only to give the sides of the boiler a light coating by feeding it with salt water from the commencement. This preventive is usually resorted to in practice, but by this protective process the greasy substances are not removed, but will accumulate in the boiler, and, unless removed from time to time by blowing out, they will form over the incrustation of salt the thick deposits alluded to, thus exposing the plates to the danger of combustion and contracting the steam and water space of the boiler. If, however, the remedy of blowing off these substances be resorted to, rather considerable losses of heat are occasioned, which will counterbalance a portion of the advantages derived from the production of steam from distilled water. It follows that the problem to be solved consists in preventing these greasy acids entering the boiler at all, *i.e.* in abstracting them from the feed water before it finds its way into the boiler. As far back as two years ago we have been engaged in the solution of this problem, and thought of the employment of a coal filter to remove the grease from the water on its way from the condenser to the boiler, a very old principle, which was patented for England recently by one Mr. James Howden.

Unfortunately we were not in a position to make experiments on a large scale, though those made on a small scale yielded excellent results. We therefore agree with the patentee, but would suggest to use, instead of one filter, two filtration apparatus, constructed more in keeping with the purpose, more readily accessible and separate from the engine, and arrange them so that the one may be cleaned, *i.e.* the coal powder impregnated with grease be replaced by a fresh filling, while the other is at work. In this manner the clarification of the water might take place without any interruption of the working of the engine. The waste coal from the filter might be revived by washing and baking, and the grease be saponized or used as a lighting material.

A marine boiler, fed with distilled or clarified water, will work under no less favorable conditions than a stationary boiler, and it is to be expected that, by preventing the external oxidation very frequently on board ships, its durability may be rendered almost equal to that of a stationary boiler. To obtain this result it would be necessary to put the shell of the barrel, which in a marine boiler is destroyed first, into a condition identical with that in stationary boilers. The more intense corrosion in the barrel in feeding with salt water is produced on the

one hand by the fact that no protective incrustation is formed above the level of the water, and consequently the salt water, raised mechanically by the balancing of the ship and the ascending steam bubbles, will cover the metallic sides; on the other hand, by the method at present in use of constructing marine boilers, the chimney hood will pass across the barrel of the boiler, and form a heating surface surrounded by steam, not by water, and it is just at the level of the chimney hood that the corrosion will be strongest, a fact which is easily accounted for.

In the quick heating of the cold boiler, this part, which is touched neither by water nor steam but by the flame itself, may soon get up to incandescent heat, and this may take place through strong heating, even during the voyage, especially when flues, tubes, &c., are covered only with a thin coating of incrustation, and the gaseous products of combustion passing through are no longer properly cooled. In this case the red-hot plate will obviously be oxidized. The chimney hood not being covered with incrustation, the nascent protoxide of iron may be separated by the change of the temperature produced by spray, or dissolved by the acids of grease and their vapors, by means of which the formation of a new layer of protoxide is facilitated.

In feeding, however, the steam generator with *pure* water, oxidation of the plates cannot take place in the barrel any more than in any other part of the boiler, and, as regards the usual chimney hood, it will involve no constructive difficulties to suppress it altogether, and in lieu thereof lead the gases derived from the combustion immediately out of the boiler after their passage through the tubes, and pass them into a copper superheating apparatus at the front of the boiler and thence into the chimney. In such arrangement *all* iron heating surfaces will be surrounded by the water of the boiler, and as copper is not destroyed by superheating, all postulates will be complied with to secure to marine boilers a durability equal to that of stationary boilers. The additional expense for copper instead of iron in the superheating apparatus would be amply balanced by the economical advantages realized in other respects.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, December 20, 1865.

The meeting was called to order with the Vice President, John H. Towne, Esq., in the chair.

The minutes of the last meeting were read and approved. The minutes of the Board of Managers were reported, including the following resignations: Messrs. Frederick Graff, Wm. A. Mitchell, and George Harding; and the following donations to the library: From the Royal Society, the Royal Astronomical Society, and the Institute of Actuaries, London; the Canadian Institute, Toronto, and the Natural History Society of Montreal, Canada; the Nova Scotian Institute of Natural Sciences, Halifax, Nova Scotia; Capt. J. M. Gilliss, Super-

intendent U. S. Naval Observatory, the Agricultural Department, and Frederick Emmerick, Esq., Washington, D. C; Thomas W. Bakewell, Esq., Cincinnati, Ohio; and Prof. John F. Frazer, Philadelphia.

The various Standing Committees reported their minutes, and the Special Committee on experiments in steam expansion reported progress.

On motion of Prof. John F. Frazer, the meeting then went into nomination of officers for the ensuing year, when the following nominations were made: For President, Wm. Sellers, Esq.; Vice President, J. H. Towne; Secretary, Henry Morton; Treasurer, Frederick Fraley.

For the Board of Managers to fill the places of those whose term of office has expired: Washington Jones, Esq., B. H. Bartol, C. H. Cramp, P. E. Chase, C. S. Close, J. H. Whitney, James Dougherty, J. V. Merrick, and Robert C. Cornelius.

To fill the vacancies caused by resignations from the Board: Wm. B. Bement, John Rice, Edward Y. Townsend.

For Auditor, Samuel Mason. The President then appointed for Judges of Election, George Erety, Samuel Hart, James H. Cresson, Wm. Biddle, James T. Morris, Charles McManus, Clarence S. Bement.

Prof. FAIRMAN ROGERS read a paper upon the magnetism of iron vessels and the methods of correcting ships' compasses. The investigations and experiments of Poisson, Airy, Evans, and Smith were described, and the results at which they had arrived explained and commented upon.

The fundamental equation representing the action of the ship upon the compass was considered, and the mode of calculating the magnetic elements of the ship, from a series of observations, explained.

The speaker suggested that the subject possessed great interest at this time, owing to the large number of iron vessels in our navy, and to the unusual forms of many of them. Experiments and observations are going on under the care of the Compass Commission appointed by the government, and by officers especially detailed by the Department, which will undoubtedly add something to the stock of knowledge upon several points yet requiring further elucidation.

The methods now in use of correcting the errors of ships' compasses mechanically, and some new forms of compass devised for the purpose of overcoming difficulties, were described.

The Report of the Resident Secretary on new inventions and discoveries was then read as follows:

SECRETARY'S REPORT.

We see from a paper read by Mr. Prentice, before the British Association, that the use of gun-cotton in mining operations is decidedly increasing, and that this substance appears to possess, among other advantages, the great merit of producing a smoke less in quantity and far less injurious in effect than gunpowder or other similar compounds. This statement is fully substantiated by the report of the Commis-

sioners on Mines of Great Britain. For soft rock the efficiency of the charge is greatly increased by winding the cotton on a light wooden core, and thus diffusing it. This was, of course, to be expected from the experiments of Prof. Abel, published in the *Journal* of this Institute, volume xlix, pages 37, 133, and 189.

The material beton, now receiving so general and extended an application, has been lately used in Paris for the construction of arched floors in some extensive barracks.

The material is simply moulded on timber centerings placed between the walls, which are 13 feet apart, and when it has set, these are removed, leaving the beton arches to support themselves. These arches having, as already indicated, a spring of 13 feet, are 2 feet thick at the spring and 10 inches at the crown.

The underground tube or tunnel of the London Pneumatic Despatch Railway, has been finished from Holborn to Easton Station, a distance of two miles. The diameter of the tube is 4 feet 6 inches. A train of goods with an attendant was sent through the whole distance in five minutes.

In a paper on weldless tires, read before the British Institution of Civil Engineers, by F. J. Bramwell, C.E., we find a full description of the manufacture, according to Bodmer's principle, of these articles. In brief, this is as follows: A helical coil of bar iron is made up, welded, and rolled into a tire of double the thickness and half the diameter required in the finished article. This is then worked down to the required form in the continuous rolling machine adapted for such operations.

By the Bessemer process, steel is being manufactured and worked into rails, &c., at the Crewe Locomotive Works, a double steam hammer being used in the forging, and the spectroscope employed as a means of observation, and prospectively as a guide in the process of conversion.

In looking over the set of abstracts of the proceedings of the Royal Institution, which have been just received, we notice several papers of an interesting character, relating to the physical constitution of the sun. It is worthy of remark, however, that though these papers seem to be the result of very elaborate observations, research, and comparisons, they develop little that is new; serving chiefly to confirm the observations and conclusions published long ago by Herschel. Thus we have, in the first place, a paper On the Nature of Sun Spots, by W. De la Rue, Balfour Stewart, and Benjamin Loewy. By comparison of extensive tables showing the behavior of sun spots in various positions, these gentlemen find that of those near the equator, 86 per ct. act as if the spot were a hollow, 14 per ct. in discordance with that supposition. Of the spots observed in high solar latitudes, 80.9 per ct. agree with, and 19.1 per ct. oppose the same hypothesis. Again, in observations made on the position of the faculae or ridges of luminous matter accompanying sun spots, out of 1137 observations, in 584 cases the faculae were on the left of the spot, in 508 equally distributed, and in 45 cases only were most on the right of the spot. This

leads to the conclusion that these faculæ consist of luminous matter projected from the locality of the spot, and, coming into a higher region of more rapid absolute motion, fall back in the general rotation of the whole system. It was also occasionally observed that bridges of this luminous matter, and even detached portions, crossed the spots without being accompanied by any penumbra.

In a second part of the same paper are recorded observations from which it would appear that the formation of sun spots is connected with the influence of the planet Venus, these being restrained and checked when she is in front of the sun, and increased in her absence.

In another paper On the Physical Aspect of the Sun, by John Phillips, reasons are shown for regarding the sun spots as *very shallow* depressions.

Physics.—Two papers in the same abstracts, record experiments by Balfour Stewart and P. G. Tait, which seem to indicate that the mere act of rotation of a body, such as a disk of wood or metal, will cause it to give off radiant heat, irrespective of any effect of friction against the air or other like medium. Thus, it was found that the disk being rotated in an exhausted receiver, and giving out more heat than when it was at rest, no change was produced in the amount of its radiation by a notable variation of the tension of the air in the receiver, or even when the vacuum was made upon hydrogen.

In the *Comptes Rendus* of the French Academy, we find the statement by M. Bultinck, that by the substitution of magnesium for zinc in the intenser forms of galvanic piles, as good an effect may be obtained with pure water for the exciting liquid, as could be reached with the latter metal by employing an acid or saline solution. For medical purposes, where short duration, intense current, and cleanliness of materials are the main objects, such an arrangement may be of value.

Mr. Carey Lea, of this city, states that he has found the operation of plating glass by deposit of metallic silver from solution, greatly facilitated by the action of strong sunlight, and recommends the exposure of the plate, prepared with its layer of solution, to the direct sun rays for from fifteen minutes to the time required to dry up the solution, according to the thickness of coating desired.

M. Fremy, in the course of his examinations regarding the nature, actions, &c., of hydraulic cement, finds that the aluminates of lime, when fused, absorb sulphur and phosphorus, and are also more fusible than the corresponding silicates. These facts are of importance in the reduction of metallic ores generally.

Devilé mixes alumina and pounded marble in equal parts, heats this highly, and then mixes the resultant so obtained with an equal quantity of alumina obtained by the decomposition of ammonia alum at the lowest possible temperature. He thus obtains a substance from which to manufacture refractory crucibles of remarkable endurance.

A mixture of thoroughly dried clay with about half its weight of glycerine, is stated in the *Cosmos* to furnish a good substitute for wax in modeling.

Ilmenium, a new element, first announced by the chemist Hermann in 1845, and whose elementary character was denied by Rose and Blomstrand, is now re-announced by its original discoverer.

Pelouze has shown that as sulphur gives to glass a yellow tint, so selenium communicates an orange tint.

A process is now used in London by which statuette likenesses, busts, &c., may be produced in clay or plaster at a small cost by the aid of photography. The operation is as follows: Eight photographs are taken of the sitter from eight "sides." From each of these profiles are cut out in thin sheet metal. Each pair of profiles are caused to plane away the sides of a block of clay corresponding to the position in which their photograph was taken. Thus, the clay comes to have on each side the same profile as that of the sitter, and is thus a likeness requiring but a few touches from the artist to give it finish and exactness.

It appears that the "carbon printing" photographic process has been applied to the permanent ornamentation of porcelain with success, any material fit for burning into that substance being substituted for the carbon or india ink of the original operation.

Mr. J. N. Herder, in a lecture lately delivered, shows that if powder, rendered non-explosive by Gale's process, is gently jarred or shaken for a few minutes, the coarser particles of the powder rise up, while the finer sand, glass, or the like, settles down, and thus the mixture loses its protection and is as explosive as ever.

Mr. Warren De la Rue has taken many good photographs of the late lunar eclipse, and by combining one of these with a similar picture taken on a previous occasion, has produced a stereoscopic view giving a remarkable effect.

The attention of the meeting was then called to a new form of the magnesium lamp, manufactured by the American Magnesium Company, of Boston. It burns with great steadiness and certainty, and gives a light decidedly brighter than that obtained from an excellent oxohydrogen lime light. (This was demonstrated by actual comparison, and photometric measurement, executed in presence of the meeting.) In this lamp the clock-work feeds forward a double strip of magnesium ribbon, and trims off the ash as it forms; a method is also in use for "fixing" some of the smoke. No difficulty is experienced in the use of this apparatus from the deposit of the magnesia smoke upon the glasses placed in front of the light to diffuse or color it, and subsequent experiments indicated the possibility of using this light behind lenses in the rougher sort of optical apparatus, such as the magic lantern.

A curious phenomenon, before recorded, was strikingly exhibited in the course of some of the experiments tried at this meeting.

When the light from either of the sources was colored by passing through stained glass, the shadows of objects thrown from that light were of the complementary color, though the points so shaded were illuminated by pure white light only, from the other source.

After some questions and remarks upon this subject, the meeting was, on motion, adjourned.

H. MORTON, *Secretary*.

BIBLIOGRAPHICAL NOTICES.

The Student's Practical Chemistry; a Text-book on Chemical Physics and Inorganic and Organic Chemistry. By HENRY MORTON, A.M., and ALBERT R. LEEDS, A.M. Philadelphia: J. B. Lippincott & Co., 1866. 12 mo., pp. 311.

This neat little volume is intended simply as a text-book, and more especially as a text-book for those attending the lectures of the Franklin Institute. It is intended as a popular explanation of the principal phenomena of physical science, and avoids much detail and all technically mathematical expositions. Its teaching is exclusively experimental and intended for beginners only. There is no doubt there is room for such a work among those daily issuing from our press, and a great desire among readers to possess such a manual. Without questioning the ultimate advantage of gratifying such desire, it is but fair to say that this little treatise is excellent of its kind, clear in its statements, lucid in its explanations, the experiments well selected for the demonstration of the desired phenomenon, and the book very well illustrated with wood-cuts. Great care has also been used to bring it down to the date of its publication, so that the reader will find in its pages an account of all the principal new discoveries in physical science. These remarks apply peculiarly to the branch of chemical physics; the chemistry proper would probably be improved by a careful revision in a future edition. The work is put before the public in excellent type and in a style creditable to its well known publishers.

On the Strength of Cast Iron Pillars, with Tables for the use of Engineers, Architects, and Builders. By JAMES B. FRANCIS, Civil Engineer. Extracted from the proceedings of the American Academy of Arts and Sciences. New York: Van Nostrand, 1865. 8 mo., pp. 71.

This memoir begins with an account of the experiments of Hodgkinson, which form the basis of all our formulæ and tables for strength of cast iron. This account is followed by the rules for calculating the strength, and by a series of tables of the safe weights for cast iron pillars of lengths from 8 to 30 feet, and outside diameters from 2 to 10 inches. It is, of course, a strictly practical and professional work, which none but the professions interested will fully appreciate, but which every member of these professions will desire to have for constant reference. It is, of course, cleanly and beautifully printed, and handsomely got out by the publisher.

A Comparison of some of the Meteorological Phenomena of NOVEMBER, 1865, with those of NOVEMBER, 1864, and of the same month for FIFTEEN years, at Philadelphia, Pa. Barometer 60 feet above mean tide in the Delaware River. Latitude $39^{\circ} 57\frac{1}{2}'$ N.; Longitude $75^{\circ} 11\frac{1}{4}'$ W. from Greenwich. By J. A. KIRKPATRICK, A. M.

	November, 1865.	November, 1864.	November, for 15 years.
Thermometer—Highest—degree, .	66.00°	69.00°	80.00°
“ “ date, .	17th.	30th.	1st, '60.
“ Warmest day—mean, .	62.33	65.17	72.30
“ “ date, .	17th.	9th.	9th, '57.
“ Lowest—degree, .	26.00	25.00	16.00
“ “ date, .	11th.	24th.	25th, '60.
“ Coldest day—mean, .	33.00	28.83	23.30
“ “ date, .	11th.	23d.	25th, '60.
“ Mean daily oscillation, .	11.63	10.80	13.16
“ “ range, .	4.73	5.84	5.65
“ Means at 7 A. M., .	41.43	41.30	41.20
“ “ 2 P. M., .	49.63	49.22	50.24
“ “ 9 P. M., .	44.45	44.57	44.41
“ “ for the month, .	45.17	45.03	45.28
Barometer—Highest—inches, .	30.405 ins.	30.347 ins.	30.661 ins.
“ “ date, .	10th.	25th.	12th, '51.
“ Greatest mean daily press. .	30.387	30.321	30.520
“ “ date, .	11th.	24th.	12th, '51.
“ Lowest—inches, .	29.895	29.080	29.080
“ “ date, .	22d.	4th.	4th, '64.
“ Least mean daily press, .	29.443	29.150	29.150
“ “ date, .	22d.	4th.	4th, '64.
“ Mean daily range, .	0.156	0.208	0.184
“ Means at 7 A. M., .	29.901	29.848	29.909
“ “ 2 P. M., .	29.837	29.803	29.864
“ “ 9 P. M., .	29.877	29.849	29.896
“ “ for the month, .	29.872	29.833	29.890
Force of Vapor—Greatest—inches, .	0.534 in.	0.548 in.	0.832 in.
“ “ date, .	17th.	10th.	8th, '57.
“ Least—inches, .	.094	.082	.055
“ “ date, .	28th.	24th.	25th, '57.
“ Means at 7 A. M., .	.201	.218	.223
“ “ 2 P. M., .	.218	.227	.229
“ “ 9 P. M., .	.217	.227	.232
“ “ for the month, .	.212	.224	.228
Relative Humidity—Greatest—per ct., .	96.0 per ct.	94.0 per ct.	100.0 per ct.
“ “ date, .	21st.	7th.	often.
“ Least—per ct., .	33.0	30.0	25.0
“ “ date, .	13th.	30th.	7th, '63.
“ Means at 7 A. M., .	74.6	76.2	77.2
“ “ 2 P. M., .	58.7	60.9	59.0
“ “ 9 P. M., .	70.2	72.2	73.3
“ “ for the month, .	67.8	69.8	69.8
Clouds—Number of clear days,* .	12	5	8.5
“ “ cloudy days, .	18	25	21.5
“ Means of sky cov'd at 7 A. M., .	57.7 per ct.	72.7 per ct.	60.6 per ct.
“ “ 2 P. M., .	55.0	73.0	60.5
“ “ 9 P. M., .	39.3	59.7	52.0
“ “ for the month, .	50.7	68.5	57.7
Rain—Amount, .	3.598 ins.	4.065 ins.	3.766 ins.
No. of days on which Rain fell, .	6	13	10.3
Prevailing Winds—Times in 1000, .	N51°46'W .255	S83°40'W .269	N71°34'W .262

* Sky one-third or less covered at the hours of observation.

A Comparison of some of the Meteorological Phenomena of the AUTUMN of 1863 with that of 1864, and of the same Season for FIFTEEN years, at Philadelphia, Pa. Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½' N.; Longitude 75° 11¼' W. from Greenwich. By J. A. KIRKPATRICK, A. M.

	Autumn, 1865.	Autumn, 1864.	Autumn, for 15 years.
Thermometer—Highest—degree, . .	89·00°	81·00°	95·00°
“ date, . . .	Sep. 4th & 6th.	Sep. 24th.	Sep. 12th '51
Warmest day—mean, . . .	82·50	75·00	85·20
“ date, . . .	Sep. 12th.	Sep. 24th.	Sep. 6th '54
Lowest—degree, . . .	26·00	25·00	16·60
“ date, . . .	Nov. 11th.	Nov. 24th.	Nov. 25th '60
Coldest day—mean, . . .	33·00	28·83	23·30
“ date, . . .	Nov. 11th.	Nov. 23d.	Nov. 25th '60
Mean daily oscillation, . . .	11·62	12·09	14·87
“ “ range, . . .	4·89	5·07	5·25
Means at 7 A. M., . . .	54·90	51·54	51·87
“ 2 P. M., . . .	62·54	59·79	62·56
“ 9 P. M., . . .	57·57	54·69	55·57
“ for the Autumn, . . .	58·34	55·34	56·67
Barometer—Highest—inches, . . .	30·405 ins.	30·347 ins.	30·661 ins.
“ date, . . .	Nov. 10th.	Nov. 25th.	Nov. 12th '51
Greatest mean daily press., . . .	30·387	30·321	30·520
“ date, . . .	Nov. 11th.	Nov. 24th.	Nov. 12th '51
Lowest—inches, . . .	29·155	29·080	29·012
“ date, . . .	Oct. 15th.	Nov. 4th.	Oct. 26th '57
Least mean daily press., . . .	29·226	29·150	29·059
“ date, . . .	Oct. 19th.	Nov. 4th.	Oct. 26th '57
Mean daily range, . . .	0·145	0·147	0·150
Means at 7 A. M., . . .	29·876	29·783	29·924
“ 2 P. M., . . .	29·824	29·746	29·882
“ 9 P. M., . . .	29·865	29·790	29·909
“ for the Autumn, . . .	29·855	29·773	29·935
Force of Vapor—Greatest—inches, . .	0·874 in.	0·741 in.	0·991 in.
“ date, . . .	Sep. 14th.	Sep. 24th.	Sep. 6th '54
Least—inches, . . .	·094	·082	·055
“ date, . . .	Nov. 28th.	Nov. 24th.	Nov. 25th '57
Means at 7 A. M., . . .	·366	·313	·338
“ 2 P. M., . . .	·373	·317	·355
“ 9 P. M., . . .	·382	·327	·357
“ for the Autumn, . . .	·374	·319	·350
Relative Humidity—Greatest—per ct., .	96·0 per ct.	97·0 per ct.	100·0 per ct.
“ date, . . .	Nov. 21st.	Sep. 5th.	often.
Least—per ct., . . .	33·0	30·0	23·0
“ date, . . .	Nov. 13th.	Nov. 30th.	Oct. 21st '59
Means at 7 A. M., . . .	74·2	74·5	77·6
“ 2 P. M., . . .	58·0	57·5	57·2
“ 9 P. M., . . .	70·4	70·8	73·4
“ for Autumn, . . .	67·5	67·6	69·4
Clouds—Number of clear days,* . . .	31	25	29·2
“ cloudy days, . . .	60	66	61·8
Means of sky cov'd at 7 A. M., . . .	60·6 per ct.	63·3 per ct.	57·9 per ct.
“ “ “ 2 P. M., . . .	55·8	69·5	26·3
“ “ “ 9 P. M., . . .	36·7	47·3	42·6
“ “ for Autumn, . . .	51·0	60·0	52·3
Rain—Amount, ...	13·532 ins.	13·111 ins.	10·894 ins.
No. of days on which rain fell, . . .	22	34	27·3
Prevailing Winds—Times in 1000, . .	N 77° 28' W 218	S 83° 48' W 253	N 78° 10' W 227

* Sky one-third or less covered at the hours of observation.

JOURNAL
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FOR THE
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FEBRUARY, 1866.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

The Bourdon Pressure Gauge. By JOHN T. HAWKINS, First Asst. Engineer, U. S. Navy.

On page 365 of the December number of the *Journal* for 1865, I find an article on the Bourdon Pressure Gauge, by John D. Van Buren, in which he exhibits very conclusively that one of the causes of the motion of the free end of a flattened tube, arranged as in Fig. 1, resulting from internal pressure, is the tendency of the tube to assume a cylindrical form, or rather, a circular form of transverse section; and that the motion produced by an excess of external pressure is the result of its tendency to still further depart from the circular form of transverse section, in the first case increasing, and in the last diminishing its volume for a constant periphery.

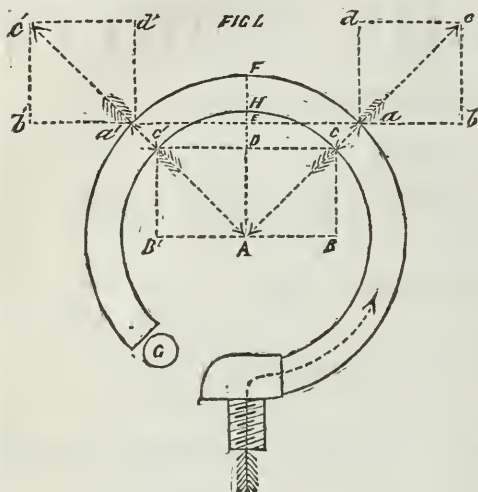
So far as that demonstration goes, Mr. Van Buren is undoubtedly correct; but he thereafter, in an appended note, attempts to disprove the commonly accepted theory of what is certainly one of the causes of the motion of the free end of the tube, and thereby falls into a very common error: that of making one natural principle solely responsible for phenomena really involving several.

It was not necessary, in order to establish the soundness of his reasoning in the original article, to attempt to upset so unceremoniously an equally sound principle, and one that can be easily shown to be one of the causes of the known actions of this gauge.

It is proposed to show that internal pressure does diminish the curvature of this flattened tube, by virtue of the greater area contained in the outer circumference, notwithstanding the statement that this would enable us to "make motors (prime) of our boots by tugging at

the straps," and that a hollow crescent with an excess of internal pressure would "fly even to its heavenly prototype."

Let Fig. 1 represent the tube of a Bourdon gauge, except that a transverse section of it be circular, as shown at G; in which case, of course, its volume cannot be increased by any change in the form of its transverse section. Take any two points $c\ c'$ upon the interior,



and two others $a\ a'$, upon the exterior circumference, such that the lines $c\ a$ and $c'\ a'$ shall radiate from the centre of curvature A. Let $c\ A$, $a\ c$, $c'\ A$, and $a'\ c'$ represent respectively the direction and intensity of the internal pressures at those points, all being equal. Each of these forces may be resolved into two, one acting vertically and the other horizontally. Let us see the effect of the eight components of these four forces. The

horizontal components $a\ b$ and $a'\ b'$ operate to diminish the curvature of the line $a\ F\ a'$, acting upon a lever $= EF = \text{ver sin of the angle } CAD$ for radius $= AF$. The components $c\ D$ and $c'\ D$ in like manner operate to increase the curvature of the line $c\ H\ c'$, acting upon a lever $= DH = \text{ver sin of the same angle for the lesser radius } AH$. The components $a\ b$ and $a'\ b'$, then, preponderate to diminish the curvature of $a\ F\ a'$. Again, the components $a\ d$ and $a'\ d'$ acting vertically operate to diminish the curvature of $a\ F\ a'$ upon a lever $= a\ E$, or $a'\ E = \sin$ of the angle CAD for radius $= AF$, while the components $c\ B$ and $c'\ B'$ operate to increase the curvature of $c\ H\ c'$ upon the lesser lever $c\ D$ or $c'\ D = \sin$ of the same angle for the lesser radius AH , the preponderance being again in favor of diminishing the curvature of $a\ F\ a'$.

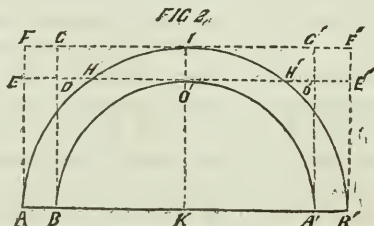
The result of this is, plainly, to straighten the segment of the tube included between the points taken, and yet the sum of the vertical components acting upward are exactly equal to those acting downward, and the sum of the horizontal components acting in one direction exactly equals the sum of those acting in the other; so we see that the thing would not take its flight in any direction if free to move, notwithstanding that there really is a greater area acted upon by the internal pressure in the line $a\ F\ a'$ than in $c\ H\ c'$, and that the same is the case for every other segment of the tube.

Now, if the tube have an elliptical transverse section, with the major axis perpendicular to the plane of its curvature, the same conditions obtain, except that the material of the tube is in such position that

it can be straightened with greater facility, the diminished difference in the radii AF and AH being compensated for by the increased major axis of the transverse section, with a decrease in the amount of material presented edgewise to resist its becoming straightened; thus the operation of the forces shown are the most effective in assisting to produce the motions of the gauge, the more the transverse section departs from the circular form in this particular direction.

It only becomes a question, then, whether the straightening of the tube is brought about most by the tendency to assume a circular transverse section, in order to increase its volume, or by the operation of the pressure upon the excess of area contained in the outer circumference.

Let Fig. 2 represent a semi-circular tube, having a circular transverse section, as in Fig. 1, the ends AB and $A'B'$ being closed, and conceive an excess of pressure to exist within it. The sum of the forces acting vertically downward upon all the surface comprised in the ends, and the inner semi-circumference, may be represented by the projecting line AB' , and in like manner those acting upwards upon the outer semi-circumference by the equal projecting line FE , the upward and downward forces are therefore equal, and this form of the instrument *could not get away from us* in either of these directions.



Again, all the forces acting horizontally against the interior of the outer semi-circumference may be divided into two equal and opposite ones, represented by the projecting lines FA and $F'B'$, and in the same manner the forces acting horizontally upon the convex surface of the interior semi-circumference may be represented by the projecting lines DB and $D'A'$; and, therefore, we may release the instrument unconditionally, *without fear of its betaking itself off to parts unknown*. Yet we see that the force represented by the projecting lines FA and $F'B'$ exceed those represented by DB and $D'A'$ by the quantity represented by the lines FE and $F'E'$. The result of this is clearly that the ends of the tube must be separated by internal pressure, although no alteration in the form of its transverse section can possibly increase its volume with a constant periphery. This is a natural consequence of the undeniable fact that the outer circumference of a Bourdon, or any other curved tube, contains a greater area than the inner one.

To follow Mr. Van Buren's own illustration in the appended note: Suppose the parallelogram $CKB'E'$, Fig. 2, to represent by its sides CK and $E'B'$ the forces acting horizontally "to push the elementary areas" CA' and $H'B'$ "in the direction of the parallel lines" CE' and $B'K$ "are equal and opposite," these forces "being measured by the equal projections" CK and $E'B'$, and that the same is the case with the parallelogram $CKAE$ and "the elementary areas" CB and HA .

On the same principle the forces represented by the projecting lines FE and $F'E'$ tend only "to push the elementary areas" $I H$ and $I H$ *asunder* "in the direction of the parallel lines" CE and CE' .

The lines FE and $F'E'$, then, represent the value of two forces for which there are no compensating ones in the opposite directions, and therefore operate to separate the ends of the tube, acting upon a lever equal to one-half the line CI , by means of the greater area exposed to the pressure upon the inside of the semi-circle $A H I H' B'$, over that contained in the semi-circle $B C A'$.

It is to be understood that the writer does not deny that the tendency of the flattened tube to assume a circular transverse section is one of the causes of the motion produced; for he has seen it proved by experiment, that a tube flattened such that the major axis of its transverse section was parallel to the plane of its curvature, underwent an increase of curvature from internal pressure. The position of the material of the tube, however, in this case is most unfavorable to the operation of the force upon the excess of area contained in the outer circumference to straighten it, while it is quite as favorable to an alteration of the form of its transverse section as when flattened in the other direction. In the case of the true Bourdon tube the two causes operate to produce the one result, while in the experiment mentioned they are antagonistic, and the operation of causing the transverse section to approach the circular form is much easier performed than that of making the tube become less convex by the force due to the greater area of the outer circumference, and therefore would prevail until, by an alteration in the form of its transverse section, the two forces became equal, from which point the other force would preponderate, and the curvature of the tube would begin to diminish.

On the Law of Density of Saturated Steam Expressed by a New Formula. By THOMAS ROWE EDMONDS, B.A., Cantab.

From the Philosophical Magazine, July.

The expansive force of a unit weight of saturated steam, according to temperature, is usually measured by the product of the pressure P in pounds to the square foot, multiplied by the volume v in cubic feet occupied by one pound weight of such steam. The product $P v$ represents the work done or resistance overcome in foot-pounds, and is equal to the effect produced by a constant force P pounds driving a piston, whose area is one square foot, through the linear space represented by the number which expresses v in cubic feet. When the laws of pressure and volume are both known, the law of expansive force represented by the product $P v$ will be known also. But such a compound will not be entitled to the appellation of a third law, if the two formulas for P and v , when united, do not yield for result a third formula equal in simplicity to either of the two constituent formulas.

The pressure P of saturated steam, appropriate to every temperature, from -30° to $+230^{\circ}$ Centigrade, has been satisfactorily and

accurately determined through the observations of M. Regnault, published in the year 1847. The law of pressure deduced from these observations has been investigated in the *Philosophical Magazine* for March, 1865, and the formula indicating the law has been found to be

$$\text{hyp. log. } p = \frac{\alpha}{n} \left\{ 1 - \left(1 + \frac{t}{a} \right)^{-n} \right\}.$$

This formula was directly obtained from the table of pressures adopted by M. Regnault, through observing that the differential coefficient of $\log. p$, at any temperature t , was always represented by

$$\frac{d \log. p}{d t} = \alpha \left(1 + \frac{t}{a} \right)^{-\frac{1}{k}}$$

the exponent $\frac{1}{k}$ ($=n+1$) being equal to the number 2.302585, which is the hyperbolic logarithm of 10.

The first and only satisfactory observations made for determining by experiment the density of saturated steam at various temperatures, are those of Messrs. William Fairbairn and Thomas Tate. They are published in the *Philosophical Transactions* of the year 1860. The difficulties are great in the way of making correct observations on the density of saturated steam in free communication with water. Such steam has not yet been obtained in a pure state, there being always an admixture of water with such steam. Part of the water is suspended in the form of cloud or mist, and part is pressed as a film of fluid against the sides of the containing vessel. Messrs. Fairbairn and Tate appear to have overcome the chief impediments to correct observation by the use of their "saturation gauge." On examining the results obtained, it will be found that the law of progression, according to temperature for the density as given by these observations, is not much less regular than the law of progression for pressure as given by the observations of M. Regnault. It will be found that the function of the variable t , involved in the law of density, is identical with the function of the variable t , involved in the law of pressure. The differential co-efficient of $\log. p$ has already been found to be

$$+ \alpha \left(1 + \frac{t}{a} \right)^{-2.302585}$$

It will now be found that the differential co-efficient of $\log. v$ is

$$- \alpha_1 \left(1 + \frac{t}{a} \right)^{-2.302585}$$

The constant α for pressure at temperature 100°C. was found to be $+ .03580$. The new constant α_1 for volume at the same temperature, will be found to be $- .03265$.

In the investigation of the law of pressure above referred to, it has been shown (*Philosophical Magazine*, vol. xxix., p. 179) that for any given interval of temperature, the logarithm of the pressure p of saturated steam is a simple function of the logarithm of the expansive force p , of a unit weight of a perfectly elastic vapor maintained at a constant volume. The quantity p being

$$= 1 + \frac{t}{a} = e^{\frac{t}{a}},$$

it was here shown that

$$\frac{d \cdot \log. P}{d \cdot \log. p} = \alpha a p^{-n} = \alpha a e^{-n \frac{t}{a}} = \alpha a e^{\log. p}.$$

By integration was obtained for hyp. log. p ,

$$\log. P = \frac{\alpha a}{a} \left\{ 1 - e^{-n \log. p} \right\}.$$

If we put

$$\phi \log. p = \frac{a}{n} \left\{ 1 - e^{-n \log. p} \right\},$$

we get

$$\log. P = \alpha \phi \log. p, \text{ and } P = e^{\alpha \phi \log. p}.$$

The formula for the pressure of saturated steam being $P = e^{\alpha \phi \log. p}$, the formula for volume is $V = e - \alpha_1 \phi \log. p$; and the formula for the expansive force of a unit weight of such steam is

$$P V = e (\alpha - \alpha_1) \phi \log. p = e \alpha_{II} \phi \log. p.$$

The value of α in the formula for pressure has been shown to be $\cdot 03580$, which represents the rate of increase per degree (Centigrade) of the pressure at the absolute temperature 376° , or at 100° on the Centigrade scale. In order to represent the law of volume, we have to put (for the same temperature) $\alpha_1 = -\cdot 03365$; and to represent the law of expansive force we have to put $\alpha_{II} = +\cdot 00215$. We thus obtain the following expressions for pressure, volume, and expansive force, reckoned from 100° Centigrade:

$$P = e^{\alpha \phi \log. p}, \text{ and } \log. P = +\cdot 03580 \phi \log. p.$$

$$V = e - \alpha_1 \phi \log. p, \text{ and } \log. V = -\cdot 03365 \phi \log. p.$$

$$P V = e \alpha_{II} \phi \log. p, \text{ and } \log. P V = +\cdot 00215 \phi \log. p.$$

By the aid of the three foregoing equations, any one of the three quantities P , V , or $P V$ may be expressed in terms of either of the other two quantities. In order to express V in terms of P , we obtain by dividing $\log. V$ by $\log. P$

$$\begin{aligned} \frac{\log. V}{\log. P} &= -\frac{\alpha_1 \phi \log. p}{\alpha \phi \log. p} = -\frac{\alpha_1}{\alpha} = -\frac{\cdot 03365}{\cdot 03580} \\ &= -\frac{1}{1\cdot 06389} = -\cdot 939944; \end{aligned}$$

consequently,

$$V = e^{-\cdot 939944 \log. P}$$

and

$$P V = P + \cdot 060056.$$

Similarly may be obtained

$$P = V - 1\cdot 06389$$

and

$$P V = V - \cdot 06389.$$

According to the notation herein used, the quantities P , v , and Pv represent ratios of pressure, volume, and expansive force at absolute temperature $(a + t)$ to similar quantities at absolute temperature (a) degrees. That is to say, P , v , and Pv are used to represent quantities usually represented by $\frac{P}{P_0}$, $\frac{v}{v_0}$, and $\frac{Pv}{P_0 v_0}$, the quantities P_0 , v_0 , and $P_0 v_0$ being constants determined of, or assumed to be determined, by observation for the absolute temperature (a) degrees. The theoretical numbers contained in the four annexed tables have been obtained by adopting the absolute temperature 376° (corresponding to 100° C.) as the fixed point from which the variable (t) is measured. At this point $P_0 = 2116.4$ lbs. to the square foot, as determined by observation. At the same temperature, $v_0 = 26.36$ cubic feet occupied by 1 lb. weight of water when converted into steam. And at the same temperature, $P_0 v_0 = 2116.4 \times 26.36 = 55788$ foot lbs. expansive force exerted by 1 lb. weight of saturated steam. These three constants P_0 , v_0 , and $(Pv)_0$ may, however, be more conveniently denoted by the letters H , H_v , and H_{pv} .

In Table I. are exhibited the results of twenty out of the twenty-three

TABLE I.—Volumes of a unit weight of saturated steam at different temperatures, as deduced from the experiments of Messrs. Fairbairn and Tate, compared with the volumes given by the new formula and by Dr. Rankine's theory respectively.

Temperature.		Pressure of saturated steam according to Regnault.	Specific volume relative to water according to Fairbairn and Tate.	Volume of one pound weight according to			
Fahrenheit.	Centigrade.			Fairbairn and Tate	Differences.	New formula.	Rankine
°	°	Atmospheres.		Cub. ft.	Cub. ft.	Cub. ft.	Cub. ft.
136.8	58.2	.180	8275.3	132.56	— .49	123.07	132.20
155.3	68.5	.288	5333.5	85.44	— .39	85.05	85.10
159.4	70.8	.317	4920.2	78.82	— 1.19	77.53	77.64
170.9	77.2	.415	3722.3	59.63	+ .56	60.19	60.16
171.5	77.5	.421	3715.1	59.51	— .08	59.43	59.43
174.9	79.4	.455	3438.1	55.08	+ .12	55.20	55.20
182.3	83.5	.537	3051.0	48.87	— 1.57	47.30	47.28
188.3	86.8	.611	2623.4	42.02	— .17	41.85	41.81
198.8	92.7	.764	2149.5	34.43	— .50	33.93	33.94
242.9	117.2	1.793	943.1	15.11	+ .12	15.23	15.25*
244.8	118.2	1.855	908.0	14.55	+ .20	14.75	14.77
245.2	118.5	1.869	892.5	14.30	+ .34	14.64	14.67
255.5	124.2	2.238	759.4	12.17	+ .19	12.36	12.39
263.1	128.4	2.548	649.2	10.49	+ .54	10.64	10.96
267.2	130.7	2.728	635.3	10.18	+ .08	10.26	10.29
269.2	131.8	2.819	695.7	9.70	+ .25	9.95	9.98
274.8	134.9	3.017	584.4	9.36	— .22	9.14	9.16
282.6	139.2	3.500	497.2	7.96	+ .16	8.12	8.14
237.2	141.8	3.767	458.3	7.34	+ .24	7.58	7.60
292.5	144.7	4.086	433.1	6.94	+ .08	7.02	7.04

* Instead of 15.61, stated in error by Dr. Rankine.

experiments on the density of saturated steam made by Messrs. Fairbairn and Tate. Three of the experiments made at high pressure and numbered 9', 10', and 14', respectively, have been excluded because the particulars given of these experiments show them to have been defective. Nine of the selected observations were made for temperatures below 100° C. In the last column of this table are given, for purposes of comparison, the densities of saturated steam at corresponding temperatures according to Professor Rankine's theoretical tables, as stated by himself in a paper communicated to the Royal Society of Edinburgh in the year 1860. In that paper Professor Rankine expresses his opinion that the results of the experiments of Messrs. Fairbairn and Tate are in near accordance with his own theoretical tables at all temperatures. He adds, however, that at temperatures above 100° C., the aggregate of experiments indicates an excess of density above the theoretical density. This excess he states to amount on a average to .27 parts of a cubic foot, being the difference between the experimental and theoretical volumes occupied by 1 lb. weight of saturated steam. It will be found on reference to the column of differences in the table annexed, that the above discrepancy has been reduced to one-fifth part of a cubic foot. This has been effected by excluding the three defective experiments mentioned, and by correcting an erroneous number given by Professor Rankine.

In the year 1850 M. Clausius published a formula, by means of which the density of saturated steam may now be calculated. This formula is given in the *Philosophical Magazine* for August, 1851, at page 107. It contains two quantities which are superfluous, as they are not found in the new formula above given. Nevertheless, the results yielded by M. Clausius' formula for volume are nearly identical with the results of the new formula for volume. M. Clausius deduced his formula from a theory of the moving force of heat originating with M. Carnot in 1824, and improved by M. Clapeyron in 1834.

The formula of M. Clausius is an expression for the latent heat of saturated steam relative to water (L), in terms of Joule's mechanical equivalent for a unit of heat (J), absolute temperature ($a + t$), excess of volume of a unit weight of saturated steam above volume of same weight of water ($v - v_0$), and the differential co-efficient $\frac{dP}{dt}$. If v be omitted as insignificant and within the errors of observation, the formula of M. Clausius may be written thus:

$$L = \frac{1}{J} (a + t) v \frac{dP}{dt}.$$

The value of $\frac{dP}{dt}$ obtained from the new formula for pressure has been shown to be

$$P a \left(1 + \frac{t}{a} \right)^{-(n+1)}$$

If this value be substituted in the formula of Clausius, we shall have

$$L = \frac{1}{J} (a + t) v \times P a \left(1 + \frac{t}{a}\right)^{-(n+1)} = \frac{1}{J} a a P v \left(1 + \frac{t}{a}\right)^{-n}$$

$$L = \frac{1}{J} a a P v p^{-n}$$

In the preceding equation the variables L and $P v$ represent ratios to constants L_0 and $P_0 v_0$. The actual latent heat is represented by $L \times L_0$, and the actual expansive force by $P v \times P_0 v_0$. On substitution of these values in this equation, we get

$$L \times L_0 = \frac{1}{J} \cdot a a P v \times P_0 v_0 p^{-n}$$

or, separating variables from constants, we have

$$L = \frac{1}{J} \cdot \frac{a a P_0 v_0}{L_0} P v p^{-n}$$

If $t = 0$, we have

$$P v = 1, p^{-n} = 1, \text{ and } L_0 = 1;$$

consequently,

$$1 = \frac{1}{J} \cdot \frac{a a P_0 v_0}{L_0} \text{ or } J = \frac{a a P_0 v_0}{L};$$

that is,

$$J = \frac{.0358 \times 376 \times 2116.4 \times 26.36}{536.5} = 1399.7.$$

The quantity J , whose value has thus been determined to be 1399.7, is the mechanical equivalent in foot-pounds of a Centigrade unit of heat, the corresponding equivalent for a Fahrenheit unit of heat being 777 foot-pounds. The value of such mechanical equivalent, as determined by Dr. Joule, is 1389.6 for a Centigrade unit, or 772 for a Fahrenheit unit of heat. If the constant v_0 be assumed to represent 26.17 cubic feet instead of 26.36 cubic feet, the resulting value of J will be identical with the value adopted by Dr. Joule himself.

It having been found that

$$L = \frac{1}{J} \frac{a a P_0 v_0}{L_0} P v p^{-n} \text{ and } J = \frac{a a P_0 v_0}{L_0},$$

it follows that

$$L = P v p^{-n}$$

an equation which represents the corresponding values of L and $P v$, when the latent heat, as well as the expansive force at the absolute temperature a , whence t is measured, are taken equal to unity.

By means of the last equation and the formula for $P v$ in terms of $\log. p$, the latent heat may be expressed in terms of the differential coefficient of the expansive force $P v$. The formula gives on differentiation,

$$\frac{d. \log. P v}{d. \log. p} = a_{11} a p^{-n} \text{ or } P v \frac{d. \log. P v}{d. \log. p} = a_{11} a P v p^{-n};$$

consequently, since

$$\frac{d \cdot P V}{P V} = d \log. P V \text{ and } L = P V p^{-n}$$

$$\frac{d \cdot P V}{d \cdot \log. p} = \alpha_{11} \alpha P V p^{-n} = \alpha_{11} \alpha L = 80140 L ;$$

that is, the latent heat of saturated steam (relative to water at the same temperature) is equal to the differential co-efficient of the expansive force $P V$, divided by $\alpha_{11} \alpha (= .80840)$.

By means of the differential co-efficient of $\log. P V$ above given, we may find the temperature at which $d \cdot \log. P V$ becomes equal to $d \cdot \log. p$; that is, the temperature at which the rate of increment of the expansive force of a unit weight of saturated steam is equal to the rate of increment

TABLE II.—Volumes occupied by a unit weight of saturated steam at different temperatures, according to the new formula, the formula of M. Clausius, and the formula of Dr. Rankine, respectively.

Temperature.			v.	v × H ₁ .		
			Relative volume according to new formula.	Volume of one pound weight of saturated steam according to		
Fahren-heit.	Centi-grade.	Absolute.		New formula.	Clausius.	Rankine.
°	°	°		Cubic feet.	Cubic feet.	Cubic feet.
32	0	276	12360	3258	3350	3390
50	10	286	6400	1687	1722	1732
68	20	296	3486	919.0	932.7	934.6
86	30	306	1988	524.0	529.5	529.2
104	40	316	1180	311.2	313.4	312.8
122	50	326	727.2	191.8	192.5	192.0
140	60	336	463.0	122.1	122.4	122.0
158	70	346	303.8	80.08	80.18	80.02
176	80	356	204.8	53.98	54.01	53.92
194	90	366	141.5	37.80	37.30	37.26
212	100	376	100.0	26.36	26.36	26.36
230	110	386	72.15	19.02	19.02	19.03
248	120	396	53.04	13.98	13.98	14.00
266	130	406	39.68	10.46	10.46	10.48
284	140	416	30.17	7.95	7.96	7.97
302	150	426	23.27	6.14	6.14	6.15
320	160	436	18.20	4.80	4.80	4.82
338	170	446	14.42	3.80	3.80	3.81
356	180	456	11.55	3.05	3.05	3.06
374	190	466	9.360	2.47	2.47	2.48
392	200	476	7.661	2.02	2.02	2.02
410	210	486	6.330	1.67	1.67	1.67
428	220	496	5.276	1.39	1.38	1.39
446	230	506	4.434	1.17	1.16	{ (not stated)

of expansive force of a unit weight of a perfectly elastic gas maintained at a constant volume. Since

TABLE III.—The expansive force of a unit weight of saturated steam at different temperatures, according to three different formulas, compared with the expansive force of a unit weight of a perfectly elastic gas maintained at a perfect volume.

Temperature.		$p = 1 \pm \frac{t}{a}$	P V.		$P H \times H_{///}$	
Centi- grade.	Abso- lute.	Relative expan- sive force of a unit weight of a perfectly elas- tic vapor occu- pying a con- stant volume.	Relative expansive force of a unit weight of saturated steam.		Absolute expansive force of one pound weight of saturated steam.	
			New formula.	Clausius.	New formula.	Rankine.
°	°				Ft. lbs.	Ft. lbs.
0	273	·7340	·7351	·7557	41008	41589
10	286	·7606	·7966	·7824	42769	43170
20	296	·7872	·7970	·8088	44461	44730
30	306	·8138	·8261	·8348	46085	46250
40	316	·8404	·8541	·8601	47646	47720
50	326	·8670	·8809	·8847	49145	49160
60	336	·8936	·9067	·9091	50583	50560
70	346	·9202	·9315	·9326	51964	51940
80	356	·9468	·9552	·9558	53291	53250
90	366	·9734	·9781	·9781	54564	54520
100	376	1·0000	1·0000	1·0000	55788	55788
110	386	1·0266	1·0211	1·0211	56964	56960
120	396	1·0532	1·0414	1·0415	58095	58130
130	406	1·0798	1·0608	1·0611	59182	59240
140	416	1·1064	1·0796	1·0801	60228	60300
150	426	1·1330	1·0976	1·0981	61235	61320
160	436	1·1596	1·1150	1·1157	62204	62330
170	446	1·1862	1·1317	1·1319	63138	63260
180	456	1·2127	1·1479	1·1479	64037	64180
190	466	1·2393	1·1634	1·1625	64904	65040
200	476	1·2660	1·1784	1·1766	65740	65860
210	486	1·2926	1·1928	1·1894	66546	66670
220	496	1·3191	1·2068	1·2016	67236	67470
230	506	1·3457	1·2203	1·2126	68077	{ (not stated)

$$\frac{d \cdot \log. P V}{d \cdot \log. p} = a_{11} a p^{-n} = \cdot 80840 \left(1 + \frac{t}{376} \right)^{-1 \cdot 302585}$$

we shall have $d \cdot \log. P V = d \cdot \log. p$, when

$$\left(1 + \frac{t}{376} \right)^{-1 \cdot 302585} = \cdot 80840.$$

The value of t , which satisfies the above equation, is negative, and equals -56° . Consequently, the absolute temperature at which $d \cdot \log. P V = d \cdot \log. p$ is $(376 - 57)$ or 320° , which corresponds to $(320 - 276)$

or 44° of the Centigrade thermometer. The ratio $\frac{d \cdot \log. P V}{d \cdot \log. p}$ is less than unity for all temperatures above 44° C., and greater than unity for all temperatures below that point.

In Tables II. and III. the values at different temperatures of v and $p v$, given by the new formulas, are compared with similar values obtained from the published tables of Professor Rankine, and with similar values obtained from the formula for volume by M. Clausius, in combination with the new formula for pressure of saturated steam. On comparing together the three series of results, it will be perceived that for all temperatures above 60° C., the three series of results may be said to be identical with one another. At temperatures below 60° C., the two series of M. Clausius and Professor Rankine continue to agree with one another, but they disagree slightly with the results of the new formula. This disagreement arises from the circumstance, that the first two series of results are regulated by the law of latent heat adopted by M. Regnault, which law is in complete accordance with the formula $L = p v p^{-n}$ for all temperatures above 60° C., whilst it deviates slightly from such formulas for all lower temperatures.

In Table IV. will be seen, for various intervals of temperatures from 0° C. to 220° C., the relation between the numbers for latent heat given by M. Regnault, and the true numbers for latent heat which flow from

TABLE IV.—The latent heat of saturated steam according to M. Regnault, compared with the latent heat deduced from the formula of M. Clausius, which is

$$L = \frac{1}{j} (a + t) v \frac{d p}{d t} = p v p^{-n} \times \text{by a constant.}$$

Temperature.		$\left(\frac{1}{1 + \frac{1}{n}} \right)^{-n}$	$p v$.	L.	$L \times L_0$.	Latent heat, (Regnault.)	Differences.
Centi-grade.	Absolute.			$p v p^{-n}$	$p v p^{-n} \times 636.5$.		
°	°				Units of heat.	Units of heat.	Units of heat.
0	276	1.4959	.7351	1.0996	589.9	606.5	— 16.6
20	296	1.3656	.7970	1.0883	583.9	592.6	8.7
40	316	1.2541	.8541	1.0711	574.7	578.7	4.0
60	336	1.1478	.9067	1.0498	563.2	564.7	1.5
80	356	1.0738	.9552	1.0257	550.6	550.6	.0
100	376	1.0000	1.0000	1.0000	536.5	536.5	.3
120	396	.9347	1.0414	.9734	522.2	522.3	.1
140	416	.8766	1.0796	.9464	507.7	508.0	.3
160	436	.8246	1.1150	.9195	493.3	493.6	.3
180	456	.7778	1.1479	.8928	479.0	479.0	.0
200	476	.7355	1.1784	.8667	465.0	465.0	+ .7
220	496	.6971	1.2068	.8413	451.4	449.4	2.0

the adoption of M. Clausius' formula for volume, in combination with the new formula for pressure of saturated steam. It will be seen that for all temperatures above 60° C. there is no appreciable difference between experimental and theoretical numbers. At temperatures below 60° C. there is a slight discrepancy between the alleged experi-

mental numbers and the theoretical numbers. On a reference, however, to the account given by M. Regnault of the various unsatisfactory experiments which he has made for temperatures below 60° C., there will be found no ground for believing that the new law for latent heat, (expressed by the equation $L = P \vee p^{-n}$), which is indisputably true for all temperatures above 60° C., is not also true for all lower temperatures. (See *Mémoires de l'Académie*, vol. xxi., pp. 712 and 722.)

The latent heat of saturated steam adopted by M. Regnault is deduced from a well known empirical law propounded by him, as affording a near representation of the total heat absorbed by a unit weight of saturated steam during its conversion from water and its elevation in temperature from 0° C. to t° Centigrade. The total heat is called λ , and the formula is

$$\lambda = 606.5 + .305 t,$$

this quantity representing units of heat for temperature measured by the Centigrade thermometer, and a unit of heat representing the quantity of heat absorbed by a unit weight of water on elevation of its temperature from 0° C. to 1° Centigrade. The latent heat is obtained by subtracting from the "total heat" (λ) the number of units of heat absorbed by a unit weight of water whilst its temperature is being raised from 0° C. to t° Centigrade. For example, if $t = 200^{\circ}$ C., then we have

$$\lambda = 606.5 + .305 \times 200 = 667.5.$$

From this number is to be deducted the heat absorbed by a unit weight of water whilst its temperature is being elevated from 0° to 200° C. This is 200 units of heat, together with 3.2 units addition made for increased specific heat or capacity of water at 200° C. We have, consequently, the resultant latent heat of saturated steam at 200° C. = $667.5 - 203.2 = 464.3$ units of heat, which is the number adopted by M. Regnault, as stated in the last page of vol. xxi. of the *Mémoires de l'Académie*, &c.

The lowest average temperature at which observations on latent heat were made by M. Regnault was $+10^{\circ}$ C. At this point the latent heat observed is stated to have been 599.5, whilst the new formula would give 587.4 Centigrade units of heat. The difference 12.1, which is the maximum difference between theory and a selected series of experiments. M. Regnault remarks that the difficulties are great in obtaining results to be relied upon from observations on latent heat of saturated steam made at temperatures below 60° C., or at pressure less than one-fifth of an atmosphere. He says that he has tried various methods of observation at these low temperatures. He assigns no reason for the preference given to the method of observation finally adopted, and he expresses no confidence in the results which he adopts. In speaking of the "total heat" adopted for the lowest temperature observed, $+10^{\circ}$ C., M. Regnault says that he "believes that it will be found not very far from the truth."

M. Regnault's table of latent heat is mainly dependent on his em-

pirical law for "total heat" expressed by the formula $A + Bt$. This law is of extreme simplicity, and for that reason the chances are very much against its being true for the entire range of temperature from 220° C. to 0° C., to which M. Regnault tries to make it apply. That it should be found to be true from 220° C. to 60° C., is something extraordinary, and ought to satisfy all reasonable expectation. There is, however, a good reason for anticipating failure in this empirical law when extended to low temperatures. The point of temperature where the suspected failure occurs is not very distant from a remarkable point of temperature (44° C.) indicated (as already stated) by new formula by PV , where $d \cdot \log. PV = d \cdot \log. p$. It is highly improbable that an empirical law so simple as $A + Bt$ should indicate correctly the "total heat" for ranges of temperature *below* this remarkable point (44° C.) as well as for ranges of temperature *above* this point.

*On the Adhesion of Locomotive Engines and Certain Expedients for Increasing or Supplementing that Function.** By VAUGHAN PEN-DRED, C.E.

From the London Mechanics' Magazine, November, 1865.

The following is an abstract of a paper upon the above subject which was read before the Society of Engineers on Monday evening last: The author commenced by pointing out that the subject of the paper was one of the most important connected with the locomotive, but that very little precise information existed respecting it. He then proceeded to show that the motion of the engine was not alone due to the thrust of the crank-shaft on the brasses, but also directly to the pressure of the steam on the cylinder lids. He then considered at some length the theories of friction, pointing out the anomalies which exist between them and the laws of adhesion as determined by Bochet. The author continued: It would appear that if adhesion is to be relegated to the domains of friction at all, it must be classed under the head of static friction, or, as it is sometimes called, the friction of repose. When one surface rests upon another with any appreciable weight or pressure, we know that a peculiar resistance, assumed to be distinct from that due to *vis inertia*, will be encountered if we attempt to slide one surface over the other. There is some little difficulty met with in conducting such investigations, as it is not easy, although quite possible, to avoid confounding the resistance due to inertia with that of statical friction, and for this reason, perhaps, the results obtained by different experiments manifest considerable discrepancies. As matters stand, we are told upon the one hand by Morin, Rennie, and most other writers on the subject: 1st. That the co-efficient of the friction of repose is greater in all cases than that of the friction of motion. 2d. That when no lubricant is interposed, the friction of any two sur-

* It is the intention of the author of this paper to publish it *in extenso*.

faces (whether quiescent or in motion) is directly proportional to the force with which they are pressed together; that is to say, a double pressure gives double friction, triple pressure, triple friction, and so on. 3d. That when no lubricant is interposed, the amount of the friction is in every case wholly independent of the extent of surfaces in contact. 4th. That the friction of motion is wholly independent of the velocity of the motion. Now, it so happens that it has been known in a rough way for some time that these conclusions are not borne out in locomotive practice. It is generally understood, for example, that the co-efficient of adhesion increases in a more rapid ratio than the weight. Indeed, I believe George Stephenson was the first to call attention to the fact. But the character as experimentalists and philosophers possessed by such men as Morin and Rennie, puts it out of the question that we should dispute the general accuracy of the conclusions at which they have arrived, as given above. We shall get over the difficulty by remembering that all their experiments were confined to cases in which the surfaces did not sensibly cut into or abrade each other—to pressures less, indeed, than 500 lbs. or 600 lbs. per inch; and it is, therefore, quite possible that they may be strictly accurate in their deductions as far as these went, while another series of experiments, commencing where they left off, and including great pressures, would give very different results.

The only really valuable investigation of this kind, of the existence of which I am aware, is that to which I have already alluded as having been conducted by M. Bochet, and this finds its true value in the fact that it was carried out under such conditions as obtain in everyday railway practice. M. Bochet's experiments were conducted upon cases of sliding friction only, at all velocities between 0 and 27 yards per second, or about 56 miles per hour. They were made with various materials, iron of different degrees of polish, woods, hard and soft, wet and dry, resinous and not resinous, on leather and gutta-percha, and with contact surfaces of very different dimensions. In all cases the frictional surfaces appear to have been dragged under the known weights of certain railway wagons, over the surfaces of the rails in various states, wet, dry, rough, oiled, polished. We have not time to go into the details of these experiments. I can only refer those desiring minute information to M. Bochet's memoirs addressed to the Academy of Sciences of Paris. The results, however, are very remarkable. They have been printed in a very condensed form in one of our scientific periodicals; sufficiently at length, however, to answer our purpose, and I cannot do better than give them to you as they stand in the pages of the *Practical Mechanics' Journal*.

“1st. Friction, under conditions apparently perfectly identical, is never precisely alike, so that its amount cannot be represented by a well defined curved line, but by a zone through which a mean curve may be regarded as the nearest co-efficient. 2d. Friction diminishes with the velocity, other things being equal. 3d. Friction varies with the surface rubbed, other things being equal, or (and this is very important) with the specific pressure. The limits are very small when

the pressure and velocity are small, but become sensible when either is great." M. Bochet's fourth statement apparently conflicts with the every-day experiences of locomotive engine-drivers. It is simply that with iron on iron rails, the friction is the same whether the rails be dry, moist, or even greased. "5th. The state of polish powerfully affects the friction of iron on iron. 6th. There is no special increase of friction on starting from rest to motion, except for wood or leather on moist or greased rails. With iron on iron rails, dry, moist, or greased, the statical friction is precisely the same as the friction of motion while the velocity is low. The statical friction is greater, however, at high velocities."

There are three physical conditions, viz: molecular attraction, roughness of surface, and speciality of abrasion in rubbing, which, acting more or less together, appear to M. Bochet sufficient to account for all his observed facts. He assumes the co-efficient of adhesion to amount, in the case of smooth, bright wheels on rails in the same condition, to at most from $\cdot 3$ to $\cdot 2$, less a third very small co-efficient, depending on the quality of the metal, so to speak, and variable circumstances impossible to reduce to a general law. In other words, the co-efficient of no two wheels, no matter how apparently identical, will be precisely the same. For ordinary circumstances, wherein the rails are neither very brightly polished nor very smooth, M. Bochet gives the co-efficient of adhesion as varying from $\cdot 4$ to $\cdot 25$. It is unnecessary that I should enter into any consideration of the numerous results which he has obtained from experiments with other substances than iron.

The author then proceeded to consider the extent of areal contact surface, and detailed certain experiments made with a view to determine its amount in the case of engines, with drivers varying from 5 feet to 6 feet 6 inches in diameter, carrying loads of 5 tons to 5.5 tons each, and fitted for the most part with steel tires, if not quite new at least in fair order. The method pursued was very simple. A part of the rail being well cleaned, the engine was brought over this spot, and two thin strips of thin, stiff paper, or, better still, thin rolled sheet iron, $\frac{1}{1000}$ inch thick, were placed on the rail, one in advance and the other in the rear of the vertical line descending from the axle through the point of contact. These slips were then brought as closely together as the wheels would permit; that is to say, they were, so to speak, wedged under the tire until the space between this last and the rail became so narrow that metal or paper could go no further. The distance between the nearest edges was then measured, and was taken to represent the length of the area of contact with the rail approximately. Samuelson used gold leaf just as the author used sheet iron and paper. Now, it must be remembered, that so long as the tire is removed from the rail by even the thickness of a sheet of paper, no contact exists; and it is also clear that the curve of the tire near the point of contact and the surface of the rail very closely approximate to the condition of parallel lines; in other words, the curve of the tire and the line of the rail subtend so small an angle, that we are justified

in considering that a considerable deduction may be made from the length of contact surface, as given by these experiments. Now, the mean of six distinct experiments carefully enough conducted gave the distance at $1\frac{3}{8}$ inch. It is true that in one other instance the distance was as great as $2\frac{3}{4}$ inches, but this occurred with a tire a good deal worn, and so it happened that the part just beneath the balance weight within the rim was the place selected to rest on the rail, and here a flat existed, due possibly to the well known influence of the weight when in rotation. After making every allowance and deduction, we may safely assume that, with a good rail well supported, and steel tires in fair order, the contact surface does not measure more than 1 inch in length, while its breadth may average $1\frac{3}{4}$ inch, say 2 inches. These numbers multiplied into each other give us a superficial area of contact of two square inches. The loads, therefore, must in practice exceed 2.5 tons per square inch as a rule. They considerably exceeded 1 ton, and were, therefore, in excess of the pressures experimented upon by Morin, Rennie, &c., and the foregoing data fully bear out the assertion. Furthermore, the pressure over the entire contact area is not constant; it rises from nothing towards the edges to a maximum near the centre of the area, where doubtless pressures equivalent to five and six tons to the inch may exist.

The value of the co-efficient of adhesion was then considered by the author, which in his opinion was usually underestimated. In proof of this opinion he adduced several illustrations selected from the performances of engines both here and abroad. After noticing at some length the various schemes which have been advanced from time to time for increasing adhesion, such as Blenkinsopp's rack rail and Brunton's feet, &c., he came to the consideration of more modern improvements in this direction. To follow the author: Up to the year 1835 rack rails and mechanical feet were the popular devices for overcoming the difficulty, to which we may, perhaps, add Chapman's chain, which, after all, is but a modification of the rack. After a time it came to be understood that smooth tired wheels and smooth rails could alone meet the mechanical exigencies of the railway system, and to Messrs. C. B. Vignoles and John Ericsson must be attributed the honor of first practically reconciling the conditions—smoothness of gripping surface with increase of adhesion. Their patent was taken out as far back as the year 1830, but it received little or no attention at the time, possibly because racks and feet held full possession of all the favor which could be spared from the smooth tire. Indeed, until the date of the trials with Mr. Fell's locomotive at Whalley Bridge, very few engineers knew anything whatever of the invention by Messrs. Ericsson and Vignoles of the only system which, at the present moment, holds out a prospect of enabling locomotives to work gradients of more than 1 in 20 with economy and certainty. A very few words will explain the whole principle. The adhesion of a locomotive is a result of the forcible contact of its wheels with the rails, the force being due to the weight of the machine. Adhesion, therefore, is so far limited by the

weight of the engine. But it is obvious that a wheel may be forced against a rail by other agencies as well as mere weight. Thus, a central rail being provided, two horizontal wheels may be made to grip it between them, precisely as the rolls of an iron mill seize a bar; and if these wheels are pressed together with sufficient force, and are caused to revolve, the engine will be compelled to move forward; and this pressure may be quite independent of the weight of the machine. In Messrs. Vignoles and Ericsson's engine the central rail is gripped between two horizontal wheels. On the upper end of the shaft of the larger of these is fitted a bevel wheel, taking into another bevel wheel on the crank-shaft. A beam is affixed to the frame of the engine; it carries the bearings of the gripping wheels. Those of one, the smaller of the two, are fitted with a species of lever arrangement easily understood, by which it was to be forced against the rail, in order that the adhesion of the larger wheel might be called into play. The inventors proposed to employ manual power, which would be obviously insufficient for the required purpose. This fact, of course, does not affect the general principle. The author continued: Mr. Fell had taken out a patent early in 1863 for the use of the mid-rail, somewhat as proposed by Vignoles and Ericsson. In saying this I do not wish to detract from Mr. Fell's originality. Indeed, I think it very possible that, considering the obscurity enwrapping the inventions of both Ericsson and Sellers, he believed himself to be the true and original inventor of the scheme. Shortly after he secured his patent, the subject was taken up warmly by Mr. Brassey, and Mr. Alexander, of the Canada Works, Birkenhead, was consulted on the practicability of constructing an engine on Mr. Fell's system. The result was that an order was given for the building of an engine without delay. In fact, every other consideration save promptitude was put on one side, and, as often happens in those cases, no time was left for working out the designs. Mr. Alexander took the matter in hand, and an engine was built. This engine weighs, loaded, 14 tons 10 cwt., the boiler is 7 feet 9½ inches long, and 2 feet 9 inches in diameter. It is fitted with 100 tubes, 1½ inch diameter, externally. There is a heating surface of 420 square feet and a grate area of 6 feet 6 inches. It will be seen that the engine has four cylinders, two outside, 11¾ inches diameter, with 18 inches stroke, working four coupled vertical wheels, on which the entire weight of the machine is supported, 2 feet 3 inches in diameter. There is nothing remarkable in any respect about this department of the machinery, and we may, therefore, dismiss it without further notice. Beneath the centre line of the boiler, and at considerably higher level than the outside cylinders, two others, 11 inches in diameter and 10 inches stroke, are fixed, facing each other. The valve chests are placed below the cylinders, and the valves are put in motion by a link much the same as that ordinarily used, except that it is curved the reverse way, although movable, because the eccentrics are not both on the same shaft. Below the carriage are fitted eight axle boxes carrying four vertical shafts of great strength. On the upper ends of each of these is keyed a crank. The pins of these cranks are laid hold of by

rods coupling them in pairs. On the lower ends of the shafts are keyed four horizontal driving wheels, 1 foot 4 inches in diameter, which, as arranged, grip between them the mid-rail. This rail is the ordinary double-headed variety, bolted to suitable sleepers. The eccentrics for working the valve of the leading cylinder are keyed one on each of the forward grip wheel shafts. Those for working the valve of the after cylinder are in like manner keyed one on each of the trailing shafts. A flat iron table is bolted to the frame to support each link. The links are provided with suitable bosses to slide on these tables. Reversing is simply effected in the usual way from the foot-plate. The eccentrics for the outside cylinders are keyed on the leading horizontal axle, as they could not be provided for elsewhere.

(To be continued.)

For the Journal of the Franklin Institute.

Moment of Inertia of Surfaces. By DE VOLSON WOOD, Prof. C.E., University of Michigan.

In the investigation of the resistance of beams or columns, the moment of inertia of the transverse sections plays a very important part. We may always deduce the moment of inertia of a surface from the well known expression $\iint y^2 dy dx$; but we may often facilitate operations by deducing from it some general rules. It is my purpose in the following article to give a general discussion of the subject, and apply each principle in the development to the solution of a problem.

GENERAL EXPRESSION.

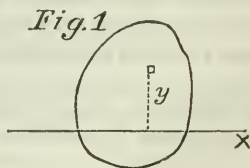
The moment of inertia of a surface is the sum of the products found by multiplying each elementary area by the square of its distance from any assumed axis.

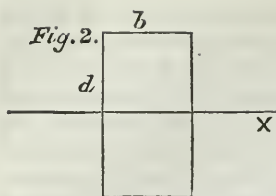
Let dA = an elementary area.
 y = its distance from the axis.
 and I = the moment of inertia of the surface.

Then, according to the definition,
 $y^2 dA$ = the moment of inertia of an element,
 and $I = \int y^2 dA$, ... (1.)

Let the surface be referred to rectangular co-ordinates. Then $dA = dy dx$;

$$\therefore I = \iint y^2 dy dx, \quad . \quad . \quad . \quad . \quad . \quad (2.)$$



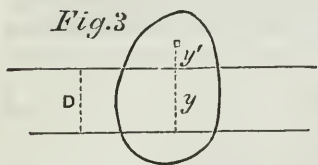


EXAMPLE.—To find the moment of inertia of a rectangle about an axis passing through the centre and parallel to the ends.

Let b = the breadth, d = the depth; then we have

$$I = \int_0^b \int_{-\frac{1}{2}d}^{+\frac{1}{2}d} y^2 dy dx = \frac{1}{12} d^3 \int_0^b dx = \frac{1}{12} b d^3 (3.)$$

FORMULA OF REDUCTION.



To find the relation between the moments of inertia about two parallel axes, one of which passes through the centre of gravity.

Let D = the distance between them.

y^1 = the ordinate from the axis which passes through the centre.

Let y = the ordinate from the other axis.

I^1 = the moment of inertia about the axis through the centre.

We have $y = D + y^1$; hence (1) becomes

$$\int y^2 dA = \int y^1{}^2 dA + \int 2D y^1 dA + D^2 \int dA.$$

But, because x^1 passes through the centre, we have $2D \int y^1 dA = 0$,

when it is integrated so as to include the whole area, and $\int dA = A$;

hence, we find

$$\int y^2 dA = \int y^1{}^2 dA + D^2 A.$$

$$\text{or } I = I^1 + D^2 A, \quad . \quad . \quad . \quad (4.)$$

This is called the *formula of reduction*, and may thus be enunciated: The moment of inertia of a surface about any axis, equals the moment of inertia about an axis parallel to it which passes through the centre, *plus* the area into the square of the distance between them.

EXAMPLE.—To find the moment of inertia of a rectangle about an axis which coincides with one end. The distance between the axes will be $\frac{1}{2}d = D$, and $A = bd$; hence, (4) and (3) will give

$$I = \frac{1}{12} b d^3 + \frac{1}{4} d^2. \quad b d = \frac{1}{3} b d^2, \quad . \quad . \quad . \quad . \quad (5.)$$

From (4) we find

$$I^1 = I - D^2 A, \quad . \quad . \quad . \quad . \quad (6.)$$

which is sometimes very convenient.

For instance, it is easier to find the moment of inertia of a triangle, about an axis which passes through its apex, and parallel to the base, than about any other axis; but having found this, we may easily find it about an axis parallel to it which passes through the centre.

To illustrate,

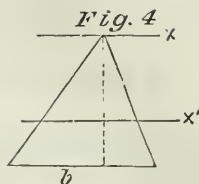
Let b = the base, and
 d = the altitude of the triangle.

Then, taking the origin at the vertex, and we have

$$x : y :: b : d \therefore x = \frac{b}{d} y,$$

and (2) becomes

$$I = \int_0^d y^2 x dy = \frac{b}{d} \int_0^d y^3 dy = \frac{1}{4} b d^3, \quad (7.)$$



The area = $\frac{1}{2} b d = A$.

$D = \frac{2}{3} d$ = the distance from the vertex to the centre; hence, (6) becomes

$$I^1 = \frac{1}{4} b d - \frac{1}{2} b d \times \frac{4}{9} d^2 = \frac{1}{36} b d^3, \quad (8.)$$

If the base be the axis, (8) and (4) give

$$I = \frac{1}{36} b d^3 + \frac{1}{2} b d \times \frac{1}{9} d^3 = \frac{1}{12} b d^3, \quad (9.)$$

RELATION BETWEEN RECTANGULAR AXES.

We will now find the relation between the moments of inertia about the axes of two systems of rectangular co-ordinates, having the same origin, but inclined to each other.

Let o , Fig. 5, be the origin, and
 $yo y^1 = xo x^1 = \beta$.

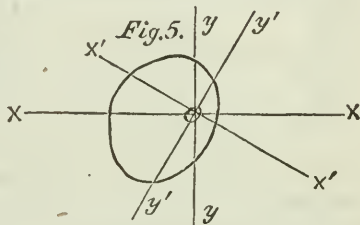
Also, I_x = the moment of inertia about $xo x$.

I_y = the moment of inertia about $yo y$.

I_{x^1} = the moment of inertia about $x^1 o x^1$.

I_{y^1} = the moment of inertia about $y^1 o y^1$.

Then, by the definition, we have



$$I_x = \int y^2 dA, \quad I_y = \int x^2 dA, \quad (10.)$$

$$I_{x^1} = \int y^{1^2} dA, \quad I_{y^1} = \int x^{1^2} dA, \quad (11.)$$

For the transformation of rectangular co-ordinates, we have

$$\left. \begin{aligned} x^1 &= x \cos \beta - y \sin \beta \\ y^1 &= x \sin \beta + y \cos \beta \end{aligned} \right\} \quad (12.)$$

Hence, we have

$$x^{1^2} + y^{1^2} = x^2 + y^2,$$

which is called an *isotropic function*, (from the Greek $\iota\varsigma\omicron\varsigma$, equal, and $\tau\epsilon\rho\omicron\pi\omega$, turning, *i.e.* the distance from the origin to any point is the same for all inclinations of the systems of co-ordinate axes.)

$$\text{Let } B = \int xy dA \text{ and } B^1 = \int x^1 y^1 dA, \quad (13.)$$

Then, by combining (10), (11), (12), and (13), we readily find the following equations:

$$\left. \begin{aligned} I_{x1} &= I_x \cos^2 \beta + I_y \sin^2 \beta - 2B \cos \beta \sin \beta \\ I_{y1} &= I_y \sin^2 \beta + I_x \cos^2 \beta + 2B \cos \beta \sin \beta \\ B^1 &= (I_x - I_y) \cos \beta \sin \beta + B (\cos^2 \beta - \sin^2 \beta) \end{aligned} \right\} \quad (14).$$

By adding the 1st and 2d of (14), we find

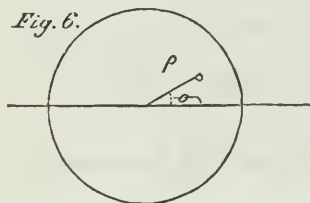
$$I_{x1} + I_{y1} = I_x + I_y, \quad . \quad . \quad . \quad (15.)$$

which is *isotropic*; and from which we see that *the sum of the moments of inertia about pairs of rectangular axes having the same origin is constant*.

From (10) and (15) we readily find that

$$I_x + I_y = I_{x1} + I_{y1} = \int (x^2 + y^2) dA = \int \rho^2 dA, \quad . \quad (16.)$$

in which $x^2 + y^2 = \rho^2$ = a variable distance; and hence, from the definition, equation (16) is the moment of inertia about an axis perpendicular to the plane of the surface. This is called the *polar moment of inertia*. We see that it equals the sum of the moments about two rectangular axes which lie in the surface, and whose origin is on the polar axis.



Let θ = the variable angle; then will $\rho d\rho d\theta$ = an elementary polar area = dA ; hence, (16) becomes

$$\iint \rho^3 d\rho d\theta = I^p = \text{the polar moment of inertia}, \quad . \quad . \quad (17.)$$

EXAMPLES.—1. To find the polar moment of inertia of a circle, about an axis passing through its centre, we have only to integrate (17) between the limits 0 and r for ρ , and 0 and 2π for θ ; hence, we have

$$I_p = \int_0^{2\pi} \int_0^r \rho^3 d\rho d\theta = \frac{1}{2} \pi r^4, \quad . \quad . \quad (18.)$$

2. We may find in the same way that we found equation (3) that the moment of inertia of a rectangle about an axis passing through its centre and parallel to its sides, is $\frac{1}{12} b^3 d$; hence, the polar moment of a rectangle about an axis passing through its centre is, by equation (16),

$$I_p = \frac{1}{12} b d (b^2 + d^2) = \frac{1}{12} A (\text{diagonal})^2, \quad . \quad . \quad (19.)$$

that is, it equals one-twelfth the area multiplied by the square of the diagonal.

Knowing the polar moment, it is easy, in some cases, to find the moment about an axis in the surface.

For instance, if the moments about the rectangular axes are equal, equation (16) will give

$$2 \int x^2 dA = \int \rho^2 dA; \quad \therefore I_x = \frac{1}{2} I_p, \quad . \quad . \quad . \quad (20.)$$

Hence, equations (20) and (18) give, for the moment of inertia of a circle, about an axis in the surface, and passing through the centre,

$$I = \frac{1}{4} \pi r^4, \quad . \quad . \quad . \quad (21.)$$

and, for the moment of a square about an axis in the surface, parallel to one side and passing through the centre, (20) and (19) will give

$$I = \frac{1}{24} b^2 (b^2 + b^2) = \frac{1}{12} b^4.$$

If the polar moment and one of the rectangular moments are known, the other rectangular moment may be easily found; for equation (16) gives—

$$I_y = I_p - I_x, \quad . \quad . \quad . \quad . \quad (21.)$$

MAXIMUM AND MINIMUM MOMENTS.

To find the position of the axes (for any assumed origin) which shall give a maximum moment about one axis and minimum about the other, we will suppose that I_x , I_y , and B , have been found for any assumed position of the axis.

By differentiating the first of (14), and placing it equal zero, we find

$$\begin{aligned} D_\beta &= -2(I_x - I_y) \cos \beta \sin \beta + 2B(\sin^2 \beta - \cos^2 \beta) = 0; \\ \therefore \frac{-2B}{I_x - I_y} &= \frac{2 \cos \beta \sin \beta}{\sin^2 \beta - \cos^2 \beta} = \tan 2\beta, \quad . \quad (22.) \end{aligned}$$

The second derivative, placed equal zero, gives $\tan 2\beta = \pm 1$; hence, of the two values of β found from (22), one will give the position of I_{x_1} for a maximum, and the other the position for a minimum.

Proceeding in a similar way with the second of (14), and we find that when I_{x_1} is a maximum, I_{y_1} is a minimum, and *vice versa*. Equation (22) in the third of (14) gives $B^1 = 0$.

Let β_1 be the value of β found by equation (22), and $x_1 y_1$ the corresponding axes, called *principal axes*.

$B^1 = B_1 = 0$, and (14) becomes

$$\left. \begin{aligned} I_{x_1} &= I_x \cos^2 \beta_1 + I_y \sin^2 \beta_1 - 2B \cos \beta_1 \sin \beta_1 \\ I_{y_1} &= I_x \sin^2 \beta_1 + I_y \cos^2 \beta_1 + 2B \cos \beta_1 \sin \beta_1 \\ 0 &= (I_x - I_y) \cos \beta_1 \sin \beta_1 + B(\cos^2 \beta_1 - \sin^2 \beta_1) \end{aligned} \right\} \quad (23.)$$

By adding the 1st and 2d of (23), and then multiplying them together, using the 3d in the reduction, we find

$$\begin{aligned} I_{x_1} + I_{y_1} &= I_x + I_y, \\ I_{x_1} I_{y_1} &= I_x I_y - B^2, \\ \therefore I_{x_1} &= \frac{1}{2}(I_x + I_y) + \sqrt{\frac{1}{4}(I_x - I_y)^2 + B^2}; \\ I_{y_1} &= \frac{1}{2}(I_x + I_y) - \sqrt{\frac{1}{4}(I_x - I_y)^2 + B^2}, \end{aligned}$$

by means of which the principal moments may be found without knowing β_1 .

EXAMPLE.—To find the principal axes of a rectangle, origin at the centre. We have already found, equation (3), that

$$\begin{aligned} I_x &= \frac{1}{12} b d^3, \text{ and } I_y = \frac{1}{12} b^3 d; \text{ we also have} \\ B &= \int_{-\frac{1}{2}d}^{\frac{1}{2}d} \int_{-\frac{1}{2}b}^{\frac{1}{2}b} xy \, dy \, dx = \left(\frac{1}{4}d^2 - \frac{1}{4}d^2\right) \int_{-\frac{1}{2}b}^{\frac{1}{2}b} x \, dx = 0, \end{aligned}$$

which in (22) gives $\beta = 0$, and these in (23) give

$$\begin{aligned} I_{x_1} &= I_x = \frac{1}{12} b d^3 \\ I_{y_1} &= I_y = \frac{1}{12} b^3 d; \end{aligned}$$

hence, those axes which are parallel to the sides and ends of the rectangle are *principal axes*.

MOMENTS IN REFERENCE TO ANY SYSTEM OF RECTANGULAR AXES, THE PRINCIPAL MOMENTS BEING KNOWN.

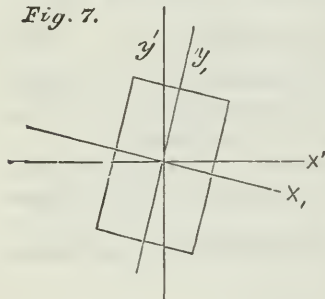
Suppose that the principal moments I_{x_1} and I_{y_1} are known, then we may easily find the moments about axes inclined at any angle; for we have only to make $I_x = I_{x_1}$, $I_y = I_{y_1}$, and $B = 0$ in (14). This done and we have

$$\left. \begin{aligned} I_{x_1} &= I_{x_1} \cos^2 \beta + I_{y_1} \sin^2 \beta \\ I_{y_1} &= I_{x_1} \sin^2 \beta + I_{y_1} \cos^2 \beta \\ B &= (I_{x_1} - I_{y_1}) \cos \beta \sin \beta \end{aligned} \right\} \quad (24.)$$

If $I_{x_1} = I_{y_1}$, then $I_{x_1} = I_{y_1}$, and the figure may be said to have its moments of inertia perfectly *isotropic*. This is the case with the circle, regular polygons, and many other symmetrical figures.

EXAMPLES.—1. Take the case of a rectangle whose sides are inclined at an angle i with the axis of x^1 . Then

Fig. 7.



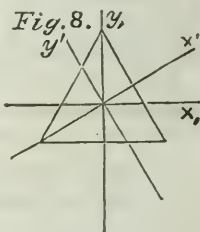
$\beta = 90^\circ - i$, and (24) gives

$$I_{x_1} = I_{x_1} \sin^2 i + I_{y_1} \cos^2 i = \frac{1}{12} b d (d^2 \sin^2 i + b^2 \cos^2 i),$$

$$I_{y_1} = I_{x_1} \cos^2 i + I_{y_1} \sin^2 i = \frac{1}{12} b d (d^2 \cos^2 i + b^2 \sin^2 i).$$

If $d = b$, then $I_{x_1} = I_{y_1} = \frac{1}{12} d^4$, the same as before found.

2. Let the section be an equilateral triangle, with the axis of symmetry inclined at an angle i with the axis of x^1 . Then $\beta = 90^\circ - i$. We easily find that $I_{y_1} = \frac{1}{48} b^3 d$, and we have



found $I_{x_1} = \frac{1}{36} b d^3$. See equation (8).

Hence, (24) becomes

$$I_{x_1} = \frac{1}{12} b d \left(\frac{1}{3} d^2 \sin^2 i + \frac{1}{4} b^2 \cos^2 i \right), \quad (25.)$$

$$I_{y_1} = \frac{1}{12} b d \left(\frac{1}{3} d^2 \cos^2 i + \frac{1}{4} b^2 \sin^2 i \right), \quad (26.)$$

MOMENT OF INERTIA OF A REGULAR POLYGON.

To find the moment of inertia of a regular polygon, let the axis of x pass through a vertex and the centre.

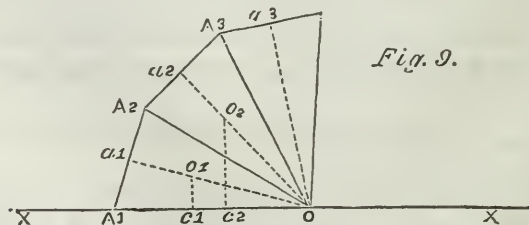


Fig. 9.

Let A_1, A_2 , &c., Fig. 9, be the polygon; o its centre; o_1, o_2 , &c., the centres of the triangles; oa_1, oa_2 , &c., the altitudes.

Let $b = A_1 A_2 = A_2 A_3 = \&c.$

$d = Oa_1 = Oa_2 =$ the altitude.

$h_1 = O_1 c_1, h_2 = O_2 c_2, \&c.$

$\alpha = A_1 O A_2 = A_2 O A_3 = \&c. =$ angle at the vortex of each triangle.

$i_1 = a_1 O A_1, i_2 = a_2 O A_1, \&c., =$ the inclination of the axis of symmetry of each triangle to the axis of x .

$k_1, k_2, k_3, \&c., =$ the moment of inertia of the successive triangles about an axis passing through their centres and parallel to OX .

$I_1, I_2, I_3, \&c., =$ the moments of inertia of the corresponding triangles about OX .

$n =$ the number of sides in the polygon.

$\alpha = \frac{1}{2} b d =$ the area of each triangle.

$A = n\alpha =$ the area of the polygon.

We have

$$\begin{array}{lll} \alpha = \frac{360}{n} & i_1 = \frac{1}{2} \alpha & h_1 = \frac{2}{3} d \sin i_1 \\ b = 2a \tan \frac{1}{2} \alpha & i_2 = \frac{3}{2} \alpha & h_2 = \frac{2}{3} d \sin i_2 \\ & \cdot & \cdot \\ & i_n = \frac{2n-1}{2} \alpha & h_n = \frac{2}{3} d \sin i_n \end{array}$$

By (25) we have

$$\begin{array}{l} k_1 = \frac{1}{6} a \left(\frac{1}{3} d^2 \sin^2 i_1 + \frac{1}{4} b^2 \cos^2 i_1 \right) \\ k_2 = \frac{1}{6} a \left(\frac{1}{3} d^2 \sin^2 i_2 + \frac{1}{4} b^2 \cos^2 i_2 \right) \\ k_3 = \frac{1}{6} a \left(\frac{1}{3} d^2 \sin^2 i_3 + \frac{1}{4} b^2 \cos^2 i_3 \right) \\ \cdot \\ i_n = \frac{1}{6} a \left(\frac{1}{3} d^2 \sin^2 i_n + \frac{1}{4} b^2 \cos^2 i_n \right) \end{array}$$

By equation (4) we have

$$\begin{array}{l} I_1 = k_1 + a h_1^2 = \frac{1}{2} a \left(d^2 \sin^2 i_1 + \frac{1}{12} b^2 \cos^2 i_1 \right) \\ I_2 = k_2 + a h_2^2 = \frac{1}{2} a \left(d^2 \sin^2 i_2 + \frac{1}{12} b^2 \cos^2 i_2 \right) \\ I_3 = k_3 + a h_3^2 = \frac{1}{2} a \left(d^2 \sin^2 i_3 + \frac{1}{12} b^2 \cos^2 i_3 \right) \\ \cdot \\ I_n = k_n + a h_n^2 = \frac{1}{2} a \left(d^2 \sin^2 i_n + \frac{1}{12} b^2 \cos^2 i_n \right). \end{array}$$

For any portion of the polygon we have

$$\Sigma I = \frac{1}{2} a \left(d^2 \Sigma \sin^2 i + \frac{1}{12} b^2 \Sigma \cos^2 i \right), \quad (27.)$$

in which $\Sigma \sin^2 i = \sin^2 \frac{1}{2} \alpha + \sin^2 \frac{3}{2} \alpha + \sin^2 \frac{5}{2} \alpha \dots + \sin^2 \frac{2n-1}{2} \alpha$

$$\Sigma \cos^2 i = \cos^2 \frac{1}{2} \alpha + \cos^2 \frac{3}{2} \alpha + \cos^2 \frac{5}{2} \alpha \dots + \cos^2 \frac{2n-1}{2} \alpha$$

For the whole polygon $\Sigma \sin^2 i = \Sigma \cos^2 i$; hence, by adding the preceding expressions, we find

$$\Sigma \sin^2 i = \Sigma \cos^2 i = \frac{1}{2} n;$$

hence, for the whole polygon, equation (27) becomes

$$I = \frac{1}{4} A \left(d^2 + \frac{1}{12} b^2 \right), \quad (28.)$$

For the square, $d = \frac{1}{2} b, A = 2b^2; \therefore I = \frac{1}{12} b^4$.

For the hexagon, $d = \frac{1}{2}b \cot 30^\circ$, $A = 3bd$; $\therefore I = 0.96214 d^4$.

For the octagon, $d = \frac{1}{2}b \cot 22\frac{1}{2}^\circ$, $A = 4bd$; $\therefore I = 0.875776 d^4$.

Let R = the radius of the circumscribing circle.

r = the radius of the inscribed circle.

Then

$$\frac{1}{4}b^2 = R^2 - d^2; \quad r = d;$$

$$\therefore (28) \text{ becomes } I = \frac{1}{12}A(R + 2r).$$

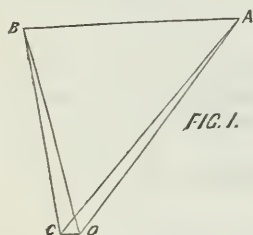
If $r = R$, then $A = \pi r^2$; $\therefore I = \frac{1}{4}\pi r^4$, which is the moment of inertia of a circle as before found.

For the Journal of the Franklin Institute.

A Mode of Determining Graphically the Correction for the Reduction to Centre of Station, and also for Oblique Illumination on Signals in a Geodesic Survey. By JOHN R. MAYER, C.E.

Reduction to the Centre of Station.

c being the centre of a trigonometrical station, o the angle observed between two objects A and B , y the angle between c and B , the left hand object, r the distance oc , D the distance Ac , and G the distance Bc .



Correction expressed in seconds

$$= \frac{r \sin(o + y)}{D} R'' - \frac{r \sin y}{G} R''.$$

In the first term call $\sin(o + y)$, a , and we

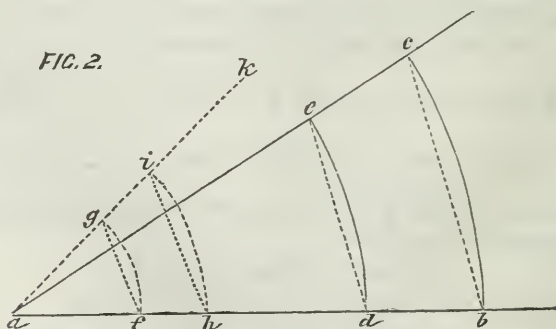
$$\text{have for this term } D : R'' :: \frac{D}{1000} : \frac{R''}{1000} ::$$

$(ra) : \text{correction for the first term.}$

The quantity ra is obtained by a fourth proportional between 90° or radius, r and a the value of this last quantity being taken from the table of natural sines.

Thus we construct a sectoral figure abc , (Fig. 2,) having ab for ra-

FIG. 2.



dius, and the transverse $bc = r$, on which the natural sine of a is marked on the lines ab and ac at d and e from the centre a , which gives de for the quantity ra .

Then, on the same figure abc , describe an arc fg , with a radius equal to $\frac{D}{1000}$, and intersect this arc at g with the quantity $\frac{R''}{1000}$, and draw the line agk . Then, from a as a centre, describe an arc with de as radius which intersects the lines ab and ak at h and i , the distance hi will represent the number of seconds for the correction of the first term.

The same operation is required for the second term,

$$\frac{r \sin y}{G} \frac{R''}{1000}$$

The rule of signs is to make the first term *positive* when $(0 + y)$ is less than 180° , and apply the negative sign with $\sin y$.

The same scale of equal parts is used for the quantities r , $\frac{D}{1000}$,

$$\frac{G}{1000}, \text{ and } \frac{R''}{1000}. \quad R'' = 206264''.8.$$

EXAMPLE.—Suppose $\phi = 51^\circ 46' 38''$, $y = 79^\circ 24'$, $r = 5.50$ feet, $D = 27659.6$ feet, and $G = 22245.4$ feet.

The graphical computation gives:

First term, $+ 30''.75$; second term, $- 50''.05$. Correction = $- 19''.30$.

The computation with the table of logarithms gives:

First term, $+ 30''.87$; second term, $- 50''.12$. Correction = $- 19''.25$.

Correction for Phase when a Tin Cone or Cylinder is used as Signal.

z being the angle observed at the station between the sun and the signal, r the radius of the signal, and D the distance.

$$\text{Correction} = + \frac{r \cos^2 \frac{1}{2} z}{D} R''.$$

Substituting $\frac{1}{2} (\cos z + 1)$ to $\cos^2 \frac{1}{2} z$ and calling β the value of $\frac{1}{2} (\cos z + 1)$ from the table of natural cosines, the quantity $r \frac{1}{2} (\cos z + 1)$ or $r \beta$, will be the fourth proportional between 90° or radius, r and β . Then, dividing D and R'' by 1000, we have

$$\frac{D}{1000} : \frac{R''}{1000} :: r \beta : \text{correction}.$$

The construction of the sectoral figure to solve this problem is like the above-mentioned, (Fig. 2.)

With a radius of *about six inches*, this mode of graphical computation gives results which can approximate to less than a *five-hundredth* of an unit.

MECHANICS, PHYSICS, AND CHEMISTRY.

On Improvements in Heavy Tools for General Engineering and Iron Ship-building Work. By Mr. JAMES FLETCHER, of Manchester.

From Newton's London Journal of Arts, August, 1865.

Forty-five years ago, at the commencement of the writer's career as a mechanic, tools were of a very rude and primitive description, the lathe and drill being about the only ones then in general use; slide lathes were possessed only by a few persons, being made with great labor and expense, and very inferior in point of workmanship.

The introduction of the planing machine, however, and its subsequent development, effected an entire change in the manufacture of tools and machinery of every class, giving the means of carrying out with facility many works which had been left unattempted previously as too expensive or impracticable, and opening the way for improvements and invention generally; and in a short time these machines became indispensable in every workshop. The slide lathe became then comparatively easy of manufacture, and, in conjunction with the planing machine and self-acting drill, formed a most important feature in the advancement of engineering work. Still, much remained to be effected; a large proportion of work was done by hand, especially the smaller portions of machinery, until slotting and shaping machines were brought into use, and special tools adapted for all parts where a quantity of work was required to be produced. By the gradual introduction and perfecting of the regulator screw, the wheel-cutting engine, standard gauges, large surface plates, long straight edges, and scraped surfaces combined with the improved tools, not only was the amount of manual labor considerably diminished, but the work was done more expeditiously, and a much greater degree of accuracy was attained, whereby the workmanship in all classes of machinery was remarkably improved, and at a great reduction in cost. As engineering skill was brought to bear on schemes which could not previously have been carried out, so were tools enlarged and new ones invented, to meet the exigencies of new works, until engineers and others became really dependent for the accuracy and execution of their work upon the tools that could be employed for the purpose. The steam engine, with all the inventive genius that has been concentrated upon it, would, without these tools, have still been most imperfect in construction, and would have formed a wide contrast to the engines erected at the present day, in point of excellence of workmanship, durability, and cost. Many instances could be given where tools of unusually large dimensions or the most minute description are indispensable for the execution of the work required.

The great change which has taken place in the substitution of wrought iron for wood or cast iron, especially in ship and bridge-building, is a subject worthy of special attention. In ship-building, the use of wrought iron has advanced with such rapid strides during the last twenty years, as to cause a complete revolution in the trade. The transition was so sudden and the demand so great, that much difficulty was experi-

enced in procuring a sufficient number of the necessary class of workmen, until those who had been previously employed as shipwrights in building wooden vessels were, in a short time, enabled, by the assistance of improved tools and appliances, to compete with more practised hands, and to cope easily with the heavy modern work. Improvements in the construction of iron ships were then rapidly developed. New tools were called for and produced, by means of which the work has been materially improved and facilitated; the edges of the plates are now planed, to make perfectly fitting joints, and multiple drilling machines are rapidly coming into use for drilling a large number of holes at once in the plates or keel bars.

Another important feature in connexion with improved tools, is the direct application of steam power to individual machines, especially those for the purpose of punching or shearing plates or cutting bars, &c., by the combination of a small steam engine with each machine; thus rendering the machines portable, entirely self-contained, and independent of other sources of driving power, and thereby saving, in many instances, the necessity of running a large engine and quantity of shafting to drive only one or two machines, when pressed for the work upon which they are engaged, and entirely dispensing with shafting and the usual attendant expenses. By this means, and by the use of an under-ground steam pipe with branches at convenient points, either in workshops or along the sides of docks, these machines may be moved about to any part required, and thus obviate the inconvenience and loss of time in carrying work to and from the machines. Steam pipes of great length are now being used, and are found very satisfactory for purposes of this description; and this plan makes a much more convenient and less costly arrangement than shafting, which requires constant attention.

In the earlier construction of the lathe, the slide rest was the first great step towards the principle of the slide lathe, and no doubt led to that invention, which was considered impracticable before planing machines were made of sufficient magnitude to plane a lathe-bed of even small dimensions. A few slide lathes had indeed been made, the beds of which were composed of a timber framing, covered with iron plates on the upper side to preserve the surface, similar to those which were previously used for the ordinary hand lathes, with the exception that the outer edges of the iron plates were made of suitable shape to form the Vs for the carriage to slide upon. It was not, however, until some time after the introduction of the planing machine that—the cost of workmanship being considerably lessened—slide lathes came into general use, and their utility was fully acknowledged, and attention directed to their improvement.

The application of a screw to the slide lathe, so as to render it capable of both sliding and screw-cutting, was the next important improvement; and a great amount of time, perseverance, and capital was expended by a few persons in endeavoring to perfect this portion of the lathe. A short screw was first made, as accurately as possible with the rude means then possessed, from which one was cut double the

length, by changing the turned bar end for end in the lathe after cutting one-half. Subsequently, by following out this principle, screws were capable of being made of any length required.

After this, the surfacing motion was introduced, and also the use of a shaft at the back of the lathe, in addition to the regulator screw, for driving the sliding motion by rack and pinion, instead of both the motions of sliding and screw-cutting being worked by the screw alone; for it was found that the threads of that portion of the screw nearest the fast head-stock, being most in use, were worn thinner than the other parts; and, in consequence, the lathe did not cut a long screw with the degree of accuracy which it otherwise would have done.

Thus, step by step, improvements were gradually brought forward; the fore-jaw and universal chucks and other important appliances were added, so as to render the lathe applicable to a great variety of work, even cutting spiral grooves in shafts, scrolls in a face-plate, skew wheels, and also turning articles of oval, spherical, or other forms. The duplex lathe, with one tool acting in front and the other behind the work, is also found to be a very useful arrangement for turning long shafts, cast iron rollers, cylinders, and a great variety of work, where a quantity of the same kind and dimensions has to be turned.

An improved lathe, referred to by the author, and designed for the purpose of turning long shafts, screws, or other articles, had a bed 40 feet long, cast in one piece, and planed the entire length at once. It is provided with two pairs of head-stocks, placed right and left hand, each pair having its own carriage and tool-rest, and working entirely independent of the other, the one pair being 15 inches high to the centre, and the other 12 inches high. In connexion with the larger head-stock is a regulator screw, running through the entire length of the bed, by means of which, when the other head-stocks are removed, a screw, $35\frac{1}{2}$ feet long, may be cut at once. The smaller head-stocks, by means of a separate shaft at the back of the lathe, are capable of sliding an article 25 feet long, and can also, if required, be provided with a screw-cutting arrangement. Thus this lathe possesses the advantages of being used as two lathes for work of an ordinary character, but at the same time a very long shaft may be turned when required. In many workshops a long lathe is an absolute necessity, although the whole length of the bed may not be required many times in the year; and unless some similar arrangement to the one above described is adopted, a large portion of the lathe-bed, taking up valuable space, would remain idle and useless the greater portion of the time. Again, in sliding long shafts, the two carriages and tools may be in operation at once upon the same piece of work, and thus economize time. The head-stocks being placed right and left hand, the loose head-stocks are thus able to accommodate each other to the different lengths of work; thereby avoiding the necessity of moving the fast head-stock and top cone-pulley when any work above half the total length of the bed is to be turned.

For turning large marine engine crank-shafts or other articles up to 40 tons weight, or screw propellers up to 20 feet diameter, the author

referred to a slide lathe, the head-stocks of which are 4 feet 6 inches high from the face of the bed, which is 40 feet long. The main driving spindle is of cast iron, 18 inches diameter in the front bearing, and 12 inches in the back bearing, arranged as an ordinary treble-geared lathe, which can be worked single, double, or treble power. The cone-pulley, the largest speed of which is 3 feet 6 inches diameter by 6 inches wide, runs loose upon the spindle. The face-plate is 12 feet diameter, and has on the back a large internal toothed wheel. By means of two pairs of driving pulleys on the counter shaft, the lathe may be worked at thirty different speeds, to suit the diameter of articles to be turned. The fast head-stock casting is in one piece, and, without spindle or appurtenances, weighs $11\frac{1}{2}$ tons. It is secured to the bed by the tie-plates. The bed is 10 feet wide over all, and is composed of two lathe-beds, each cast in one piece 40 feet long, and held firmly in a parallel position by distance feet or foundation plates, having strips and bolts to bind the beds in their places. When it is required to move the bed endways, to accommodate any large article on the face-plate, the strips in the distance feet are slackened so as to allow the two long beds to slide through them, the motion being given at the end by means of worm-wheels and screws. The end foot or distance piece nearest the fast head-stock is fixed to the long beds, and travels with them upon the tie-plates, so as to support their ends whilst turning articles on the face-plate. Two self-acting sliding carriages are employed, upon one of which is a slide rest of ordinary construction and great strength; the other carriage has a rest made very narrow, with a wrought iron tool slide, and is for the purpose of turning out crank sweeps. The self-acting motion is driven by a strap from the spindle to a pulley at the back of the lathe, and is provided with a reversing apparatus, to enable the carriage to slide in both directions. This motion can be thrown out of gear independently in either of the carriages, which are provided with an arrangement for moving them on the bed by hand. An eye bolt is screwed in the front part of the loose head-stock, and a corresponding one upon the nearest carriage, so that the two can be coupled by a short chain or shackle, and the loose head-stock can thus be drawn upon the surface of the bed, to any required position, by the hand motion of the carriage. The total weight of this lathe, which is now in course of construction for the Lancefield Forge, in Glasgow, will be upwards of 70 tons.

The planing machine is one of the most important tools in use, and has done more towards the advancement and success of engineering work than any other invention, with the exception of the lathe, and has passed through a great number of changes since its first introduction down to the present time.

In the first planing machines the table was moved by a chain winding on a drum, as in the old hand machines; but this mode was found to be very objectionable, the cut was unsteady, and when the tool was suddenly relieved at the end of its cut, the table had a tendency to spring forwards; it was also driven at the same speed both forwards and backwards, and thus a great loss of time was occasioned. This

was much improved upon by the use of a rack and pinion, arranged to give a quick return motion, and also afterwards by the screw arrangement.

In some of the earliest planing machines the Vs were made inverted, evidently with the idea of preventing any cuttings that fell upon the wearing surfaces from remaining upon them. They proved, however, to possess no advantage even in this particular, as the finer portions of the cuttings still adhered; and in addition it was found that, from the motion of the table, the oil, by its own gravity, would not remain upon the surfaces, and thus caused them to cut and wear away quickly.

The writer has in use a planing machine, with a bed 54 feet long, the Vs of which have 2 inches of surface on each side, and are planed to an angle of 85 degrees. This machine has been working upwards of twenty years, and for the last six years both night and day. It has been employed during the whole of that time upon very heavy work, ranging from 5 to 20 tons. The Vs are still in good condition, apparently very little worn, and the work the machine does is at the present time perfectly true. The bed is in three parts jointed and bolted together, and the table in two parts; since, at the time it was made, there was no machine capable of planing a very long piece, and this was considered to be one of the largest then in existence.

The planing machines were further improved by the use of two tool-boxes on the cross-slide, and by the application of slide rests or tool-boxes fixed upon the uprights, self-acting vertically, for planing articles at right angles to the tools on the cross-slide. The reversing tool-box is a very ingenious and useful contrivance for planing flat surfaces; but that plan is not so well adapted for general purposes. Planing machines have, like other tools, been specially adapted to a great variety of work, and the writer has made them with different numbers of tools up to as many as sixteen, all of which were in operation at once.

The great changes which have lately taken place in the manufacture of wrought iron and steel ordnance, and the revolution they have caused in the construction of vessels of war, have called into requisition a great many alterations and adaptations of the present machines, as well as many entirely new ones. The planing machine especially has been called upon to do work of a very curious and intricate character, namely, that of planing the edges of armor plates to different curves, shapes, or angles. In most cases this has been accomplished by a pattern bar of iron or steel, placed on edge in a small chuck fixed upon the surface of the table, adjustable by set screws, and shaped to the form to which it is required to plane the edge of the plate; as the table travels, this bar, which runs between two circular rollers attached to the under side of the cross-slide, moves the tool sideways, according to the amount of curve in the shaper or guide bar, the tool-box being disconnected for this purpose from the screw in the cross-slide.

A duplex planing machine, made by the writer, is arranged with double beds and double tables, each table having a separate set of gear-

ing, with starting, stopping, and feed motions. There are two tool-boxes on the cross-slide, each of which is independently self-acting, so as to work with its own table. Thus the two tables may be used separately as two smaller machines working independently of each other, and capable of planing different lengths of work at the same time; or when planing a large article, the two tables, gearing and motions, may be coupled, so as to form one large machine, an arrangement rendering the machine capable of doing a variety of work. Also one table may be fixed stationary as a bed-plate to bolt awkwardly-shaped or long pieces of work upon, whilst they are planed by a slide rest fixed upon the other table. When used as one machine, both sets of straps and gearing are in operation, and are reversed by the stops of one table only, so as to insure the straps moving at the same time.

This machine is capable of planing articles 10 feet wide and 10 feet high. The racks on the under side of the tables are 3 inches pitch, with stepped teeth; the wheel working into the rack is 3 feet 9 inches diameter at the pitch line, and is driven by a smaller pinion. By this arrangement a steadier motion is obtained; and also the pulleys and driving gear can be placed entirely behind the face of the uprights, so as to leave the front of the machine perfectly clear, that the straps may not be in the way when taking the work off and on. The pulleys being below the ground line, may be driven by a horizontal underground shaft at the back of the machine, and no straps will then be visible. The writer has made machines of this description with beds 40 feet long, to plane work up to 14 feet in width.

This machine is particularly well adapted for planing armor plates. Two plates can be planed at once on each table, one being placed upright and the other horizontal, so as to be operated upon by the tools on the cross-slide and the upright at the same time; or whilst two plates are being planed on one table, the workman may be fixing two more on the other, and thus keep the machine constantly employed. One workman is sufficient to attend to both sides of the machine, thereby saving labor. By having a stationary table fixed at one side of the bed, upon which the four ends of four other armor plates are bolted, and adding an angle bracket and slide rest upon one of the moving tables, the four ends are planed at the same time.

The slotting machine, of which the engineers in Glasgow can justly boast the heaviest examples, was originally introduced for cutting small wheels, levers, &c., mostly for self-acting mule and loom work, and was afterwards adapted to a great variety of work by the application of a circular table, which was an improvement of the greatest importance, especially in large machines for slotting or shaping large cranks or other similar work; this is now done to such perfection as to require merely drawfiling and polishing to give the work a perfect finish. Many kinds of quick return motions have been employed for the purpose of saving time in the return stroke of the tool, and to give it a regular and steady movement in the cutting direction. Of these, the principal are the eccentric wheels, the eccentric motion, and, lastly, the lever motion, which makes an excellent and steady movement, and is now very much applied to shaping machines.

One of the large slotting machines made by the writer has a stroke of 3 feet, and the framing is capable of taking in an article 12 feet diameter; it has compound slides and a self-acting circular table 6 feet diameter. The ram moves in a vertical slide, which can be raised or lowered to suit the depth of work on the table, so as to form a support to the ram when taking a heavy cut. The motion applied to the tool slide is the lever and connecting rod, arranged so as to gain power and give an almost uniform motion in the cutting direction, and an accelerated speed in the return stroke.

In making a double lever-punching, shearing, and angle iron cutting machine, the strong hollow cast iron frame is planed at each end for the reception of the punching and shearing slides. The machine is put in motion by a steam engine, fixed upon the outside of the framing, and connected to a crank-pin in the fly-wheel, driving by a pinion on the first motion shaft into the large wheel, which has cams cast on each side in opposite positions, so as to work alternately the pressing levers, which operate the punching and shearing slides. These levers work on fixed pins for their fulcrums. The punching slide is provided with a block, which can be drawn out from under the end of the lever to throw the punch-slide out of gear. At the shearing end an adjustable stop is added immediately in front of the shears, for holding down the plate whilst shearing, and thus causing it to be cut square on the edge. This takes the strain of holding down the plate from the workman, and prevents short pieces of metal from getting down between the cutters and breaking the machine.

Upon the end of the centre shaft is forged an eccentric, working into a block in a ram, the lower end of which is provided with suitably shaped cutters for shearing bars of angle iron. This slide is placed at an angle of 45 degrees, and has also a disengaging motion, so as to be thrown out of gear whilst a long bar of angle iron is being put between the cutters, and set to the proper place or marks for being cut off correctly.

This machine possesses all the advantages of the old lever machine and the eccentric machine combined, the former of which has long been acknowledged to be the most simple and useful. The cams which operate the pressing levers are constructed of such a shape that the operation of punching or shearing is completed, and the slide returned to the top, in half a revolution of the machine, the whole slide remaining stationary during the other half revolution, whilst the workman is adjusting the plate for the next stroke. This enables the machine to be worked one-third quicker than eccentric machines, and still leaves the workman as much time to move the plate; since in eccentric machines the punch or shears is always being either raised or lowered, instead of being stationary during part of each revolution.

For the purpose of obtaining greater accuracy in dividing out the holes in bridge, boiler, or ship plates, a dividing table has been used, and machines have been arranged to punch several holes at once. This was certainly a great improvement upon the old method, since, in addition to the accuracy attained, very much more work was accomplished

in the same amount of time. Still the work was not of a satisfactory description. In punching the holes the iron is disturbed or fractured for some little distance around the hole, thus weakening the plate; and in consequence of the taper which there must necessarily be in all punched holes, the rivets do not thoroughly fill up the space, especially when more than two plates are joined together.

The faults of punched work above mentioned were so apparent when wrought iron bridge-building became general, that they led to the introduction, by Messrs. Cochrane, of the multiple drilling machine, for drilling a large number of holes at once in bridge plates.

It has been found desirable to make this principle of drilling machine more universal in its application, and the following is a machine designed for this purpose: A strong base plate extends the entire length of the machine, about 18 feet, with three circular openings along the centre line, large enough to admit hydraulic cylinders, by which the table carrying the plate to be drilled is raised and pressed against the drills with the necessary force. The end frames are bolted to the base plate, and upon them are fixed guides adjusted to each corner of the table; they also support the girder which carries the drill frames. The ends of the girder are fitted in planed grooves, and it is made in halves, which can be set wider apart without altering the gearing, by inserting cast iron packings of the requisite thickness and longer bolts at the joint. The two halves of the girder can also be turned with the drill frames inwards if required, and adjusted to a distance of four inches apart for the two rows of holes and upwards.

Each drill is held in a separate frame. The frames are all bolted on the girder at a proper distance apart, and are moveable longitudinally to any position along the girder. Each drill spindle is fitted with an adjustable tail pin and lock nut, which receives the upward pressure of the spindle; and a conical bearing is provided at the lower end of each drill frame, which prevents the drill spindles from wearing out of truth. The drills are all turned parallel for a short distance at the upper end, and fit in parallel sockets, which admit of short drills being adjusted to the same length as longer ones, by putting some small burrs or punchings from the punching machine, of the required thickness, into the drill sockets above the drills; and the drills are fastened in the sockets by a set screw.

Each drill spindle is driven at the top by a pair of mitre wheels, which may be described as each consisting of a short section of a $3\frac{1}{4}$ inch diameter twelve-threaded screw, of which the threads are about 12 inches pitch; that is to say, each thread or tooth, if continued, would make one complete turn round its shaft in 12 inches length. A long steel shaft, $2\frac{1}{4}$ inches diameter, with a groove throughout its length, passes through each drill frame, and its vertical spur mitre wheel, giving motion to each drill spindle. This shaft is driven by a pair of strong bevil wheels in the proportion of $1\frac{1}{2}$ to 1, which take their motion direct from the pulley shaft, and give about 60 revolutions per minute for the drills.

The application of the spur mitre wheels in this machine for driving the drill spindles, enables the spindles to be arranged in such a manner that they are capable of being moved to suit different pitches of holes. In consequence, however, of the wheels being $3\frac{3}{4}$ inches diameter, holes could not be drilled at a less pitch than that dimension with a single driving shaft; but another application of the same mode of driving allows of the drill spindles being got to within $2\frac{1}{2}$ inches from centre to centre, with the same diameter of driving wheels. This is effected by using two long steel driving shafts, instead of a single one, each shaft driving every alternate drill spindle.

The hydraulic cylinders used to raise the table with the work on it up to the drills are similar to those of hydraulic presses. A pair of strong $1\frac{1}{4}$ inch diameter pumps, worked by eccentrics on a shaft, force water into an accumulator, which consists of an upright cylinder fitted with a piston properly weighted; and there is a self-acting apparatus which throws the pumps out of gear when the accumulator is full. The hydraulic cylinders are connected with the accumulator by a two-way cock, and on turning the water on the table immediately rises. When the pressure is to be removed, turning the cock back stops the pressure from the accumulator, and at the same time allows the water to escape from the cylinders, causing the table to fall immediately. The working pressure of water is about 3 cwt. per square inch, which produces a pressure of about 6 cwt. per drill. A plate is drilled in twelve to fifteen minutes. A strong parallel motion gear is fixed under the drill table to prevent it from lifting at one end when only the drills at the other end are being used, or when only one row is in use.

These drilling machines are now being used by Messrs. Kennard for drilling the plates and bars required in the main girders of the new bridge to be placed over the Thames at Blackfriars. The truth of the drilled holes is so complete that when a number of plates with holes drilled for 1 inch pins are put together indiscriminately, and four turned pins passed through the corner holes, the holes fit so accurately throughout the entire lot of plates, that a pin 1 inch diameter can be driven through the lot at any hole with a light hand hammer. In consequence of this superiority of the work, a great diminution in the cost of labor takes place in putting the parts together, saving the drifting of the holes and the strain put upon the plate which necessarily takes place when riveting punched holes. In addition to this, the fibre of the iron retains all its strength and tenacity, and there can be no doubt that the extra work of manufacture is fully compensated for by the greater strength of construction, and the decrease of cost in putting the plates together.

Several other useful machines are constructed for bridge and ship-building purposes, amongst which may be named—a machine for shearing plates up to 1 inch thick, with revolving circular shears; machines for planing plates with a traveling tool, and also with a revolving circular disk containing a number of tools; and machines for bending garboard strakes, angle iron, and deck beams for ships.

The writer next describes a nut making machine, designed to manu-

facture nuts from a heated bar of iron, at a single operation, by cutting off from the bar a piece to form the blank, which is swaged into shape, and the hole punched through it while still hot. The blank is powerfully compressed between the pair of swages while in the die-box, before the hole is punched, in order to make the nut solid and shape it with smoothness and precision; and the hole is then punched while the nut is still confined in the die-box, and under the heavy pressure of the swages, so that it is prevented from bursting or straining during the operation of punching.

The dies, swages, and punch are so fixed to the machine that they can easily be removed and replaced by others of different sizes. By this means the same machine may be used for making nuts of various sizes and shapes. Two of these machines have now been at work at the writer's works in Manchester for upwards of five years. With the aid of a good furnace, from 15 to 20 cwt. of $\frac{7}{8}$ or 1 inch nuts can be produced in a working day of 10 hours, the machine running at 60 revolutions per minute. All the nuts possess the same degree of accuracy in shape, the sides being parallel to each other, and the holes being punched perfectly central whilst the nut is under pressure in the die-box. The iron is fed into the machine at a welding heat, and the pressure put upon it by the swages in the die-box has the effect of closing up the fibres of the iron, making the nuts very much stronger than those forged in the ordinary way by hand. The holes punched are perfectly clear and regular, and have no scale inside them to injure or chafe the threads of the taps when being screwed.

The author also describes a bolt-heading machine, similar in some of its principal parts to the nut-making machine. The bar of iron for forming the bolt, heated to a welding state for a short distance only at the end, and of the same diameter as the screwed portion of the bolt, is inserted between a pair of open dies, divided longitudinally down the centre. The bolt is pushed up to the heading swage, the length of which is adjustable so as to measure off the iron to the correct length for making bolts of different thicknesses of head. As soon as the bar is inserted between the dies, a shearing slide, carrying one of the dies and the cutter, is pressed forwards, and the length for forming the bolt is cut off. The second bolt is then held firmly between the dies until the formation of the head is completed. This operation is affected by the advance of a centre ram, carrying the heading swage, which compresses the heated metal so as to fill a die-box and form the bolt-head. The heading swage then remains stationary whilst the die-box is drawn back clear of the bolt-head; after which the swage also retires to its original position. The shearing slide is then withdrawn by leaving the bolt in the stationary half of the dies; and a knocker strikes the finished bolt, and discharges it from the dies.

This machine makes about 30 strokes per minute, and is capable of producing a bolt at each stroke, provided it be supplied with the iron at a proper heat. The bar of iron is heated only at that portion which is to form the head, the remainder or bolt end being cut off cold. The object of this is to prevent the bolts from being scaled their whole

length through the action of the fire. The ram carrying the heading swage is acted upon by a cam through the intervention of a lever, through which the whole pressure is transmitted; and the bottom end of this lever is centred upon an oak beam fixed inside the framing of the machine, which, being slightly elastic, prevents the machine from being broken in the event of more iron being inserted into it than is required to make the bolt-head. In consequence of this provision a bolt has been made without breaking the machine with a head as much as $1\frac{3}{16}$ inch thick, when the dies were set to make it only $\frac{3}{4}$ inch thick.

There are a great variety of special tools, for railway and machine making purposes, which the writer has been obliged to pass over, and which would form ample material for another paper.

In conclusion, it may be remarked that the opinion is now universal that, without extraordinary strength, rigidity, and power in tools their work cannot be accomplished either quickly or well. Accuracy in the manufacture of tools and their universal application have had a great effect in the perfection of the work executed and in the facility and economy of its performance. By the assistance of gauges for different parts of machinery, the advantages of engineering tools have been more fully realized; and no engineering work, of whatever magnitude, need now remain unaccomplished for want of tools.

Notwithstanding the length of time during which the improvement of tools has been in progress, and the great advance that has been made, it may be said that at the present time there is a wider field for improvement than ever, and a constant and increasing demand for tools of novel construction for special purposes.

Number of Useful Plants.

From the London Reader, May, 1865.]

“Cosmos” states that, according to a German author, the number of useful plants has risen to about 12,000; but it must be remembered that these researches have been completed only in certain parts of the earth. There are no less than 2500 known economic plants, among which are reckoned 1100 edible fruits, berries, and seeds, 50 cereals, 40 uncultivated edible graminaceous seeds, 23 of other families, 260 comestible rhizomes, roots, and tubers, 37 onions, 420 vegetables and salads, 40 palms, 32 varieties of arrowroot, 31 sugars, 40 saleps. Vinous drinks are obtained from 200 plants, aromatics from 266. There are 50 substitutes for coffee, 129 for tea. Tannin is present in 140 plants, caoutchouc in 96, gutta percha in 7, resin and balsamic gums in 389, wax in 10, grease and essential oils in 330. 88 plants contain potash, soda, and iodine, 650 contain dyes, 47 soap, 250 fibres which serve for weaving, 44 for paper making, 48 give materials for roofing, 100 are employed for hurdles and copses. In building 740 are used, and there are 615 known poisonous plants. According to Endlicher, out of the 278 known natural families, 18 only seem up to the present time to be perfectly useless.

Professor Graham's Law of Gas Diffusion.

From the London Reader, May, 1865.

Mr. G. F. Ansell, of the Royal Mint, has proposed a novel application of Professor Graham's law of gas diffusion for the purpose of ascertaining and giving warning of the presence of accumulations of fire damp in coal mines. The apparatus described by Mr. Ansell is a glass U-tube, having one aperture closed with a plate of graphite or equivalent porous diaphragm, and a few inches of mercury in the bend. If such an arrangement, filled in the first instance with air, be placed under the influence of an atmosphere containing five per cent., or even less, of light carburetted hydrogen or marsh gas, the presence of such admixture will be instantly detected by the passage of the gas through the interstices of the graphite, and the consequent expansion in volume of the gaseous contents of the tube; the column of mercury then rises in the opposite limb of the apparatus, and is made to record itself either by completing the circuit of a voltaic alarm, by deflecting a galvanometer needle, or, lastly, by an adaptation of the simpler mechanism of a wheel barometer. We understand that the invention has been patented by Mr. Ansell, and, inasmuch as it gives great promise of successful employment, the apparatus must be deemed well worthy of immediate trial.

Cornish Engines.

From Herapath's London Railway Journal, No. 1376.

The number of pumping engines reported this month is 31. They had consumed 1905 tons of coal, and lifted 12,800,000 tons of water 10 fathoms high. The average duty of the whole is therefore 48,700,000 pounds, lifted one foot high, by the consumption of 112 pounds of coal.—*Lean's Engine Reporter for August.*

Report of the Balloon Committee.

From the London Mechanics' Magazine, September, 1865.

This report was read by Mr. Glaisher. It stated that the committee had been reappointed last year in order, first, to examine the electrical condition of the air at heights; second, to verify the law of the decrease of temperature, as found from summer-day observations already made, with day observations at other seasons of the year, but principally in the winter and the adjacent months; third, magnetical experiments, observations with the spectroscope, the currents of the atmosphere, solar radiation at different heights, and hygrometrical observations, though secondary, were held as very important subjects of investigation; fourth, to arrange for observations at night, and to make such observations if possible. With respect to the first subject no further progress had been made, the instrument prepared for the purpose not having been rendered available for use. Under the second and third heads some progress had been made, though not to the ex-

tent anticipated. As to the fourth object, no night observations had actually been made. To take such observations it was imperatively necessary to have some means of illumination, so that the instruments could be read. Various suggestions had been made on this point, but the best plan seemed to be to employ a Davy lamp. Two such lamps had been made for Mr. Glaisher of copper, so that the proximity of magnets did not affect them. Experiments had shown that these lamps might be used with perfect safety, and that they kept well alight, besides affording a source of grateful warmth not before possessed. All necessary arrangements were now made for night observations, though there were no results yet for presentation, and a series of such observations would be very useful. The same instruments, with the addition of a fine spectroscope and a delicately mounted magnet, had been employed, as during the previous year. The instruments were attached to the outside of the car, and were easily read in that position. Up to the last meeting of the Association, twenty-two ascents had been made, of which seventeen had taken place in June, July, August, and September, and five only in the other months of the year, viz: one in January, one in March, two in April, and one in October. Of the summer ascents, one had been made in the morning, and the rest in the afternoon or evening. The committee considering that day and high experiments in summer had better be brought together before more were made, Mr. Glaisher devoted all his efforts to secure as many ascents as possible between October and April, but he had succeeded in three instances only, on December 1 and 30, 1864, and on February 27 last. The three ascents were made at Woolwich, and the paths of the balloon were shown in diagrams. The small number of ascents was due to winter being an unfavorable season for balloon experiments. But as with regard to the progressive diminution of temperature with elevation, the diffusion of vapor in the atmosphere, the density of clouds, their extent, and currents in the atmosphere, and all connected with the higher regions of the atmosphere in winter, we are in almost entire ignorance. It is the most important season for experiments. Proceeding to speak briefly of the three ascents, the report stated that the balloon left the earth on December 1 at 2.37 P. M., with a temperature of 48 degrees, which remained almost unaltered till the height of 800 feet was passed. Having slightly increased up to that point, it then gradually declined to $31\frac{1}{2}$ degrees at about a mile high. On December 30 the balloon left at 2.13 P. M., with a temperature of $42\frac{1}{2}$ degrees. In the first 500 feet it inclined 2 degrees, at 1000 feet it was 37 degrees, at 2000 feet it was $33\frac{1}{2}$ degrees, at 2500 feet cloud was encountered, and the temperature was 31 degrees; at 3300, at the upper surface of the cloud, it was 27 degrees, on getting above the cloud the temperature rose, and at 400 feet above it had increased to $31\frac{1}{2}$ degrees. On February 27 the earth was left at 1.58 P. M., the temperature was 52 degrees, and declined gradually to 35 degrees, when a cloud 1000 feet in thickness was reached. In passing through this there was no change of temperature, but above it the temperature increased with elevation. Comparison established that these

results differed greatly from those obtained in summer, and showed that the laws of temperature varied at different seasons. The courses in the three ascents were very nearly the same after reaching a certain point. The winds prevailing in the higher regions in January and February were W. and S.W. This was unfortunate in regard to the ascents, as it necessarily shortened their duration. Since that time Mr. Glaisher has been making preparations for night ascents. The ascents made, however, were important in proving the constancy of the S.W. current during the winter months, which was also confirmed by observations at the Royal Academy. In the descent on December 30, Mr. Glaisher was unable to make any magnetic observations, as the balloon was in a constant state of revolution, but on other occasions he had succeeded in obtaining results which corresponded with those found at other periods of the year. At every opportunity during these ascents, Mr. Glaisher had directed the spectroscope to the sun, and always saw a very fine spectrum with many lines, more numerous than on earth and better defined. The spectrum usually extended from A to far beyond H. The spectrum was perfect, with a much narrower opening of the slit than on the ground, and lines could therefore be clearly resolved which could not be seen from the earth. A blackened bulb thermometer, placed near another carefully screened, for determining the temperature of the air, generally read the same as the latter. No tinge of ozone was shown on the test papers in any of the journeys. The report contained a mass of figures relating to the observations, which were detailed with every minuteness.

Mr. Glaisher's disappointment at finding his time for observation always cut short by the inevitable tendency of the balloon towards the sea, was compensated for when he considered the high importance of the continuance of southwest winds in winter. Constant observation last winter, from October to March, had found the wind always in the same direction, whenever it was possible to determine the motion of the upper air, no matter from what quarter the earth wind came. The high temperature we experienced in winter seemed due greatly to this current, which met with no obstruction in its course towards us, but blew directly hither and to Norway over the Atlantic. These winds only reached France when they had passed over the whole of Spain and the Pyrenees, and they had then become so much cooled that France derived comparatively little benefit from them. This apparently caused the more severe winters in that country. It was probable that our milder winters were due to these winds. After touching on the subject of the ultimate destination of the heat rays which constantly issue from the sun, Mr. Glaisher said that a few months previously he had thought that would be his last report on balloon ascents. He had devoted his entire leisure for three years to these experiments, and every day he was so occupied was a day taken from the month's holiday allowed him as an *attache* of the Royal Observatory. As, very properly, no personal expenses were allowed by the Association, he had to pay them himself, and he had also had to defray the cost of the necessarily heavy calculations. He felt, therefore, that he had per-

formed his share of these experiments, and that they might cease for the present, and fresh ones be made at a future day by others. But on seeing, in preparing this report, how deficient they still were in winter ascents and morning ascents, but, above all, in night operations, he had determined, in consultation with the committee, to make some night ascents at once, if possible, and therefore he would probably have to address them again at their next meeting.

The Explosion at the London Gas Works at Nine Elms.

From the London Journal of Gas Lighting, No. 341.

The evidence adduced at the coroner's inquest may be thus briefly recapitulated. The works of the London Gas Company at Nine Elms comprised two telescopic gasholders, about 4000 feet apart, each 150 feet in diameter, with two lifts of 30 feet, and, when filled, each one contained one million cubic feet of gas. The accident occurred about quarter past two o'clock in the afternoon, when the southern gasholder was quite full, and the northern one was about 38 feet high. Between the two gasholders, but within 20 feet of the northern one, was a building 79 feet long by 39 feet wide and 23 feet high, which contained the station meter in the centre, the governors being at the eastern end, with a second floor for store rooms, and workshops over them. The foreman's office, photometer room, &c., were at the west end of the building, with a second floor over them. The central part, occupied by the station meter, was open to the roof, on which was a glazed ventilator, extending the whole length of the meter-house. There was space enough in the building for a second meter of the largest dimensions, and in the south wall there was left an opening sufficient for the admission of the drum of the second meter, whenever it might be required. It was intended to close that opening with doors, but they had not been fixed, and the space was left open at the time of the accident. Two governors, one for a 36-inch main and the other for a 24-inch main, had been fixed on a stage raised about 2 feet high above the floor of the meter-house, and a third governor was in the course of erection. The gasholder of the larger governor was floated by an air vessel, and that of the other governor was counterbalanced by a weight suspended from the opposite extremity of a beam, each one being kept in position by friction rollers acting in three guide columns, and by three sets of friction rollers fixed round the bottom. At 11 A.M., the outlet and inlet valves being still open, the by-pass valve of the 24-inch governor was opened, and the gas was sent to the company's gasholders at Vauxhall. At about a quarter past two o'clock an alarm was raised that gas was escaping from that governor, the gasholder of which had been tilted, and several men who had been at work in the building were seen endeavoring to force it back into the governor tank. At that time the gas was rushing through the water with great violence. Two heroic servants of the company, Mr. Marven, the deputy manager, and Michael Doolan, the deputy valve man, saw the danger, and, at the imminent risk of their lives, rushed into the house

in the hope of preventing an explosion. Marven first extinguished the test light which was burning in the meter-house, and then assisted Doolan in closing the valves of the governor. They succeeded in closing the outlet valve, and had descended into the vault below the stage and had half closed the inlet valve when the explosion took place, which destroyed the entire building and buried about thirty men beneath the ruins, seven of whom were killed. The side of the gasholder next to the north wall of the meter-house was forced in with great violence, and the crown was rent open, the sheet iron plates being turned over outwards so as to make an irregularly shaped aperture of about 1200 feet area. Through that aperture the gas forced its way, and, becoming ignited, blazed fearfully for a few seconds till it had all escaped, and the gasholder descended rapidly into the tank. The eastern wall of the meter-house was forced against and crushed in a portion of the front wall of some workshops about 25 feet distant; but the southern and western walls were blown into the yard without doing much damage. The effect of the explosion on the second gasholder is most remarkable. Its nearest point to the meter-house was 320 feet, but the concussion cracked the sheet iron of the outer ring of the crown, between the rivets by which the plates were fastened to the angle iron curb, for a length of 6 or 8 feet on the side next the meter-house, and through that rent the gas escaped, and, becoming ignited, burned with great fury until all the gas was consumed. The gasholder was not further damaged, and in a few days it was repaired and again at work. One of the guide columns against which the flame impinged curved slightly during the burning of the gas, but straightened again on cooling, though a slight crack was produced which has been temporarily repaired by hooping it; but with this exception the guide columns of both gasholders are uninjured.

Of the persons buried under the ruins of the meter-house, seven were dead when extricated, three others died after having been taken to the hospital, and fifteen or twenty other men were more or less burned by the explosion. The escape of Marven and Doolan with trifling injuries is almost miraculous; but no damage appears to have been done to the pipes or valves in the chamber underground in which they were, and even the wooden stage immediately above them was only slightly injured. Neither is the station meter much damaged, such injury as it has received having been occasioned principally by the *debris* falling on the sheet iron cover, the case and the drum remaining untouched. The guides of the 24-inch governor were broken short off at the tank, but the gasholder itself was in its place, and it has been only crippled by the falling material. Thus it appears that, in the very midst of the flame, the gas in the governor, which was the cause of the accident, did not explode.

There are three ways by which gas may escape from governors as at present constructed. In the first place, by the detachment of the internal cone from the top of the gasholder, owing to the breaking of the link by which it is suspended, whereby the counterbalance weight would raise the gasholder out of the water. In the second place, the

gas may escape from want of water in the tank ; or, thirdly, by the accidental tilting or upsetting of the bell of the governor. The evidence at the inquest shows that the latter was the cause of the escape of gas at Nine Elms. The valve man, Bartlett, stated that the "seal" was 8 inches, and as the gasholder gave a pressure of only 6 inches, there were 2 inches to spare. The cone was found after the accident to be securely suspended from the governor gasholder ; therefore the accidental tilting of the bell by the plasterers at work on a scaffold in plastering the ceiling over the governor seems to be the only conclusion we can arrive at as to the cause of the escape of gas.

It is almost impossible to estimate the quantity of mixed gas and air that exploded, for the large central opening would permit all the gas below that level to pass outwards. The total capacity of the meter-house building Dr. Letheby calculates to have been 61,000 cubic feet, and the quantity of gas that might have escaped by the tilting of the smaller governor would be amply sufficient to have filled the whole area with an explosive mixture of gas and air during the few minutes that Doolan was absent to take the stock of gas. The ignition appears to have taken place at some lights in the meter testing shop, 58 feet distant from the governor. The current of mixed gas and air must have crossed a roadway between the meter-house and the workshops, and have passed through windows before its ignition ; for, with the exception of a smith's fire—which was about the same distance as the lights in the meter testing shop, but opposite to which there was not any opening in the meter-house wall—there was no other light at which the ignition could have occurred.

The verdict of "Accidental death" was the only one which the jury could have rationally given after the evidence brought before them. They evidently came to the inquiry prejudiced by the erroneous and exaggerated accounts in the papers ; but as the witnesses were examined they began to see the fallacy of those representations, and felt so satisfied by the evidence of Dr. Letheby that the gasholder did not and could not explode, that they did not require any confirmation of his statements, though Professor Pole, Mr. Siemens, and Mr. Barlow were present, and were prepared to do so.

The recommendation of the jury, that precautions should be taken to protect governors from being tampered with, has directed the attention of gas engineers to the methods most likely to effect that object. Mr. Watson, the Engineer of the London Gas Company, purposes to adopt the very effectual plan of enclosing the governors, and of carrying shafts from each through the roof into the open air. Mr. Evans, the Engineer of the Chartered Company, proposes to enclose the gasholders of governors in jackets with stuffing boxes at the top, through which the suspension rod can pass—a plan which has been already adopted by Mr. Garnett, of the Ryde Gas Works. Mr. Pritchard, of the Western Company, suggests a sheet iron jacket with a small hole in the centre of the crown, just large enough for the free working of a small wire rope by which the gasholder may be suspended. The last is the simplest, and perhaps the most practicable plan. It

does not in any degree affect the action of the instrument, and it has the additional advantage that the air confined in the jacket would form a cushion that would prevent the sudden rising of the cone by an increase of pressure, which has sometimes been the cause of the snapping of the link connecting the cone with the gasholder. The adoption of any one of these contrivances would, there could be no doubt, completely prevent the recurrence of such an accident as that at Nine Elms; but, above all things, we strongly recommend gas managers to see for themselves that the governors are perfectly charged with water, for which purpose a small stream might be constantly kept running through, as is done with station meters where great accuracy of registration is desired.

The district lighted by the London Gas Company was for one night deprived of gas illumination by the damage done to their two large gasholders; but the Chartered, the Imperial, the Phoenix, and the Equitable Gas Companies promptly offered their assistance, and the lighting was resumed on the following night.

The advocates of the system of laying gas pipes in subways ought to reflect upon what may be the consequence of constructing mines under crowded thoroughfares that are liable at any moment to be filled with mixtures of gas and atmospheric air equal in their explosive properties to the contents of the meter-house at Nine Elms, which has been the cause of such fearful destruction of life and property. The subway of the Holborn Viaduct, designed by the city architect, is of proportions and construction that would involve the destruction of the whole street, were any such accident to occur; and those in course of construction by the Metropolitan Board in the Thames Embankment, and in the new street, from Blackfriars to the Mansion House, though not so colossal in their proportions as that of the proposed Holborn Viaduct, partake of all its sources of danger, and the objections of gas companies to lay their mains in them will be greatly strengthened by the experience which this catastrophe has afforded. The Metropolitan Board would do well to rescind their resolution by which these structures are being formed in anticipation of the current of public feeling becoming sufficiently strong to drive the gas companies into them at some future time, as it is evident, from the panic which this explosion has created, that the public feeling is now setting in the opposite direction.

On Chemistry Applied to the Arts. By Dr. F. CRACE CALVERT,
F.R.S., F.C.S.

From the London Chemical News, No. 252.

(Concluded from page 34.)

LECTURE VI.

FLESH, its chief constituents, boiling and roasting. *Animal black*, its manufacture and applications. Various methods of preserving animal matters. Employment of animal refuse in the manufacture of *prussiate of potash*. A few words on the decay of organic matters, and their fermentation and putrefaction.

I shall now examine with you some of the various causes which contribute to the destruction of animal matters, when it arises from slow

decay or putrefaction. The first of these to which I shall have the pleasure of calling your attention is that observed by Dr. Stenhouse, who, in 1854, made the curious discovery that, if the body of an animal was buried in a carbonaceous mass, such as charcoal, after a few months the whole of the animal, excepting the skeleton, would entirely disappear; and what was still more remarkable was that, though the experiments were conducted within his laboratory, no unpleasant effluvia were apparent to those who were constantly there. This eminent chemist attributed the rapid and complete destruction of animal tissue in these experiments to the oxidation of the animal matters by the oxygen of the atmosphere; but to enable you fully to understand how this occurs, I must call your attention to the following facts: Lotwitz, many years since, observed that charcoal possesses the property of absorbing and condensing in its pores large quantities of various gases, and Theodore de Saussure made an extensive series of experiments, from which I extract the following data:

One cubic inch of boxwood charcoal absorbed of—

Ammonia,		90 cubic inches.
Hydrochloric acid,		85 “
Sulphurous acid,		65 “
Sulphuretted hydrogen,		55 “
Carbonic acid,		35 “
Oxygen,		10 “
Nitrogen,		7 “

Consequently, the absorption or condensation of a gas in charcoal appears to be in ratio to the solubility of the gas in water, and although the condensation by a solid and by a liquid may at first appear necessarily due to different causes, and, therefore, to bear no relation to each other, yet, in my opinion, these two actions are identical. Seeing that the gas is condensed by the molecular attraction of the solid, I do not see why the same attraction should not be exercised by the molecules of the liquid. The different degrees of solubility of various gases are no doubt owing to their respective physical properties, such as specific gravity, repulsive or expansive forces of their molecules, &c. I may here mention that I am now engaged in a series of experiments, in the hope of throwing some light on this interesting question.

Gay-Lussac, in his researches on the condensation of gases by charcoal, found that one gas may expel and take the place of another gas already condensed in the charcoal; and Dr. Stenhouse, following up this observation, states that the gases, vapors, and sporules generated by the putrefaction of animal substances are absorbed by charcoal and brought into immediate contact with the oxygen of the atmosphere also contained in the pores of the charcoal, while oxidizing or destroying the products of putrefaction converts them into water, carbonic acid, nitric acid, &c. These important scientific observations of Dr. Stenhouse have already received practical application. Thus, Mr. Haywood has established charcoal filters at the mouths of public drains, thereby arresting the escape and diffusion in the atmosphere of the noxious effluvia given off by the putrefying matters in the sewers. Further, charcoal respirators have become extensively used since Dr.

Stenhouse called public attention to the valuable properties of this substance; and, lastly, atmospheric filters, containing charcoal, have been successfully applied in the Houses of Parliament to purify the entering air from any noxious gases it may contain before passing into the building. The natural decay or destruction of organic matters is due to two perfectly distinct causes—one of them chemical and the other physiological. The former has been investigated by many of the most eminent chemists of the day, and no doubt can remain that the action of the oxygen of the atmosphere converts the carbon of organic substances into carbonic acid, the hydrogen into water, the sulphur into sulphuric acid, the nitrogen into nitric acid, the phosphorus into phosphoric acid, &c. Much light has recently been thrown upon these phenomena of M. Kuhlmann, who clearly shows that the oxides of iron play a most important part therein; thus that the sesquioxide of iron yields its oxygen to the elements of the organic matters; that the protoxide of iron thereby formed absorbs oxygen from the air, which reconverts it into sesquioxide, and this again yields its oxygen to a fresh portion of organic matter, so that sesquioxide of iron is a most powerful oxidizing agent, it being, in fact, the condenser of oxygen and the medium of its conveyance to and destruction of organic substances. MM. Chevreul and Kuhlmann have also shown that sulphate of lime acts in a similar manner, namely, that it yields its oxygen to the elements of organic substances, and is thus converted into sulphuret of calcium, which, having a great affinity for oxygen, is again rapidly converted into sulphate of lime, and thus the oxygenation and destruction of the organic matter is effected. Mr. Millon has published an interesting paper on the formation of nitre, or nitrate of potash through the ammonia generated during the destruction of organic substances being oxidized into nitric acid, which combines with potash, if present, and if not, with lime or magnesia, which are present in all soils. Mr. Millon has remarked that this important chemical reaction is effected by an organic substance called humic acid, which acid, or its homologues, exists in large quantities in all earthly loams containing much organic and more especially vegetable matters in a state of decomposition. Humic acid absorbs the oxygen of the atmosphere, which oxidizes the ammonia into nitric acid and water. The chemical theory of the destruction of organic matters through oxidation, and their absorption of plants and reversion into the same substances from which they were derived, such as sugar, starch, gum, oil, essences, &c., or albumen, fibrine, gluten, caseine, &c., was greatly in favor a few years since, as it appeared to fulfil all the requirements of nature. It has, however, been greatly shaken by the beautiful researches of M. Pasteur on fermentation, putrefaction, and spontaneous generation, which proves clearly that these physiological actions play a most active part in the destruction of organic substances. This most skilful chemist has demonstrated that there is no such thing as spontaneous generation, and that the notion entertained by some physiologists, that if matter is placed in favorable circumstances as to heat, light, &c., and in a proper medium, it will become spontaneously

animated, is undoubtedly erroneous, and that life in all instances proceeds from a germ or egg in which the vital principle is implanted by the Creator. He proves that life, even in the most insignificant of microscopic creatures, always originates thus, and that there is no single instance of matter being animated by purely physical causes. Let me draw your attention to a few among many facts observed by M. Pasteur, proving that life is not a property of matter, like weight, electricity, compressibility, &c., but is always the result of a germ, even in its lowest development.

When arterial blood is carefully introduced from the artery into a clean vessel, and there brought into contact with oxygen, no fermentation or putrefaction of the blood ensues; and if the experiment is repeated, substituting for the chemically prepared oxygen atmospheric air which has been passed through a tube containing pumice-stone and carried to intense heat, in this case also there is no putrefaction or fermentation; but if ordinary atmospheric air be used in the place of pure oxygen or heated air, and left in contact with some of the same blood, this vital fluid will rapidly putrefy, which is doubtless owing to the presence in the atmospheric air of the sporules or eggs of micoderma and vibrios, or organized ferments, which give rise to the various chemical phenomena and changes of organic matters into products which characterize fermentation and putrefaction. The same results are obtained when fresh urine is substituted for blood, an important fact, proving that the germs of fermentation do not exist in the fluids themselves, and that fermentation does not proceed from any molecular or chemical change in the composition or nature of the organic substances contained in blood and urine, but that the ferment from which these phenomena proceed is to be sought for in the atmosphere. I shall substantiate this view by several other interesting observations made by M. Pasteur.

If some asbestos is heated to a red heat and plunged into a liquor susceptible of putrefaction, such as a saccharine liquor, no fermentation ensues; but if atmospheric air is passed through asbestos at natural temperature, and the latter then immersed in a similar solution of sugar, active fermentation soon takes place, proving that the atmospheric air has left on the surface of the asbestos sporules of the micoderma vini, which being introduced with the asbestos into the saccharine fluid, originated the well-known alcoholic fermentation. Another beautiful series of experiments by M. Pasteur is the following: He introduced into 60 small balloons a small quantity of a highly putrescible fluid, and after boiling the fluid in order to drive out the remaining air in the balloons by the formation of steam, he closed the small apertures, so that on cooling the steam condensed and a vacuum was produced. He then proceeded to open 20 of these balloons at the foot of one of the hills of the Côté d'Or, 20 others at the summit of the same, (about 2000 feet high,) and the remaining 20 at a point near Chamounix, and the following results were observed: Of the first 20 balloons, the contents of 15 entered into putrefaction within a few days; of the second 20 only 6; and of the third 20 only 2 gave signs

of fermentation. These results, as well as some others, published by M. Pasteur, prove that the sporules or germs of putrefaction and fermentation exist in all parts of the atmosphere, but more abundantly in the lower strata, which are necessarily in contact with great quantities of organic matter in a state of decay, and that these sporules become scarce in the upper regions, which are further removed from the source of pollution. Further, he has proved, as I stated in my last lecture, when speaking of the preservation of milk, that fluids extremely liable to fermentation or putrefaction may be prevented from entering into those conditions by heating them to 250° or 260° , a temperature at which the sporules cannot resist decomposition in the presence of water. M. Pasteur has advanced a step further in this interesting inquiry, for he has demonstrated that there are two distinct phases in putrefaction. In the first there are the vibrios produced in the bulk of the fluid containing animal matters in solution, and these microscopic animals unfold the organic substances into more simple compounds; in the second phase, there are produced on the surface of the fluid cryptogams, which he calls mycodermis, and which absorb oxygen from the air, and oxidize the products developed by the vibrios. In the case of the fermentation of vegetable substances, such as saccharine matters, there are mycodermis, (*Mycoderma vini*), which unfold them into, say, alcohol and carbonic acid, while other mycodermis (*Mycoderma aceti*) are produced, and grow on the surface of the fluid, oxidizing the alcohol into water and acetic acid. He therefore concludes that the animal vibrios and vegetable mycodermis exist abundantly in nature, and that they must be and are the most active causes of the destruction of vegetable and animal substance which have fulfilled their vital function on the earth, reducing them into water, carbonic acid, ammonia, sulphuretted hydrogen, &c., which, in their turn, become the foods of a succeeding generation of plants and animals. We may, therefore, truly say that death is life in the constantly reviving world.

M. Pasteur has observed another most curious fact connected with these microscopic beings, (I say microscopic, because it requires a most powerful instrument and high powers to distinguish them, and to ascertain that vibrios possess a vibratory motion while mycodermis are stationary,) this is, that vibrios are the only animals which can live in pure carbonic acid, and which are killed by oxygen even diluted with another gas. Oxygen is essential to the life of mycodermis, and some of them can also exist in carbonic acid. Lastly, M. Pasteur has noticed that if a very small amount of yeast is added to a saccharine fluid, the yeast will not materially increase in quantity, because the new generation which is produced lives on the remains of its parents; but if phosphate of ammonium or of lime and some sal-ammoniac is added with the yeast, the latter will rapidly increase and occupy several times its original bulk. It is curious to observe that these microscopic cryptogams require the same kind of food as man. Thus, they require nitrogenated food—so do we. They require mineral food, as phosphates—so do we. They require respiratory food—so do we. They produce carbonic acid as part of their vital functions—so

do we. I cannot do better than conclude this part of my subject by giving the following table descriptive of the various ferments observed by M. Pasteur:

FERMENTATION.		
Mycoderma vini.	} Unfolds sugar.	{ Alcohol. Carbonic acid. Succinic acid. Glycerine.
Mycoderma aceti.		
	} Oxidizes alcohol.	{ Acetic. Water.

PUTREFACTION.

Infusorial Ferments.

Vibrios unfold animal substances.*

Bacteria oxidizes organic matters of an animal origin.

I should mislead you, however, if I did not call your attention to another class of fermentations, which are chemical in their nature and in their action. This, for example, is the case when bitter almonds are crushed and mixed with water. The amygdaline they contain is decomposed into prussic acid, hydruret of benzoil, &c., by the ferment they contain, which is called emulcine. Again, when black mustard is reduced to meal, and placed in contact with water, the myronic acid it contains is decomposed into the essential oil of mustard, a most corrosive fluid, and this is also effected by a special ferment called myrosine. Again, when malt is mashed with water of a temperature of 170° , its starch is converted into sugar by a ferment called diastase. We also know that the starch which we take into our stomachs as food is converted into sugar by animal diastase, which exists in the saliva as well as in the pancreatic juice, and that this conversion is identical with that which takes place in the mash-tub. In fact, the whole of the changes which our food undergoes to render it fit for assimilation in the digestive organs of the body may be considered as a series of different fermentations. What gives a further interest to those chemical ferments is, that not only are they all nitrogenated, and possess a chemical composition, but they present many identical properties, still each has its own peculiar action; that is, it will only cause fermentation in those matters which have been placed by nature in contact with it. Thus diastase will not convert amygdaline into prussic acid, hydruret of benzoil, &c., nor will myrosine convert starch into sugar.

In conclusion, it is certain that our knowledge of these interesting phenomena of putrefaction, fermentation, &c., is yet in its infancy, and there is no doubt that many important discoveries in this intricate branch of knowledge will, from time to time, be brought before the world, and reward science for its persevering efforts.

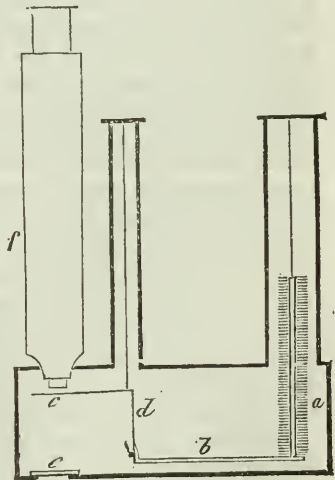
[This lecture concludes Dr. F. C. Calvert's course as delivered before the Society of Arts; on delivery, they were listened to with eagerness by a numerous auditory, and have now been read with no less pleasure than instruction.—ED. *C. N.*]

Magnetic Declination. By Dr. JOULE.

From the London Mechanics' Magazine, May, 1865.

At the ordinary meeting of the Literary and Philosophical Society, March 21, 1865, R. Angus Smith, Ph. D., F. R. S., President, in the chair, Dr. Joule described an instrument he had constructed, for showing rapidly minute changes of magnetic declination. The adjoining cut represents a section of the instrument. *a* is a column of small magnetic needles suspended by a filament of silk. Attached to its lower end is a glass lever *b*, with a hook at its end. A fine glass lever *c* is suspended by a single filament of silk, its shorter arm being connected with the first lever by means of a small hook attached to the fibre *d*. The whole is enclosed in a stout copper box, into which light is admitted through a lens *e*, cemented into an orifice immediately under the object-glass of the microscope *f*. The microscope magnifies about 300 linear, and has a micrometer in its eye-piece, with divisions corresponding to $\frac{1}{2000}$ ths of an inch. One division corresponds to a deflection of the needle of $4\frac{1}{2}''$; and as a tenth of a division can be very readily observed, the instrument measures deflections to within half a second. So rapid is the action that, on applying a small magnetic force, the index takes up its new position steadily in two seconds of time. Besides being a damper to the motion of the needle, the copper box, by its conducting power, equalizes the temperature rapidly, so that the indications are not to any considerable extent disturbed by currents of air. The success of the present instrument encourages the hope that very much greater delicacy may be obtained by a further multiplication of the motion and the use of a more powerful microscope. Dr. Joule stated that he had observed an extensive magnetic disturbance the previous evening, the index being driven entirely out of the field of view.

The President said that three meteorological instruments of true originality and of unprecedented delicacy had been described to that Society by the inventor, Dr. Joule. For common observation, the instruments were too refined, but in some fields of inquiry they seemed the only hopeful guides. Manchester had not yet a Meteorological Observatory, although the proposal had often been made to establish one. Private spirit, as in the instance of Mr. Vernon and others, had made the necessity less felt than before. But there was now an opportunity of beginning one with entirely new apparatus of Manchester origin, which would probably very much alter the quality of the inquiries made in meteorological establishments.



Mr. Baxendell stated that the Society had in its possession a thermometer constructed by the late Dr. Dalton, and which, it is believed, was used by him in many of his meteorological observations. The scale has the initials "J. D." and the year "1823" engraved upon it; and the freezing and boiling points of water are indicated on the stem by fine file marks. As it is known that the zero points of thermometers sometimes change to the extent of one or even two degrees in the course of several years, it occurred to Mr. Baxendell that it would be interesting to ascertain whether any change had taken place in this thermometer, and he had, therefore, lately tested very carefully the position of the freezing point, but found that no sensible alteration had taken place; and he believed, therefore, that great confidence might be placed in the observations which Dalton had made with this instrument.

For the Journal of the Franklin Institute.

Aboriginal Ingenuity.—The Tepiti.

Indications that American Indians were an original, and, to a certain extent, an isolated race, are to be found in mechanical devices which they had, as in others which they had not; absence in one case and their presence in the other being hardly reconcilable with foreign communication or intercourse. Tribes that became the most advanced carried out the thread-making idea without the *distaff* and *pendant spindle*; they had not the *bellows* nor *scissors*, nor is it certain that either the *domestic lamp* or *candle* was known. The Maya MS. dictionary is said to mention a "hanging star," supposed to refer to a suspended light, perhaps in the temple. Then, there is no indication of the potter's wheel in their crockery ware. Now, could any people from Europe or Asia have made anything like an early settlement on the continent, and not have introduced one or more of these? and if introduced could they have vanished without leaving a trace of one of them north or south, east or west? We learn from Garcilasso la Vega how delighted his countrymen, the Peruvians, were with scissors. A young Inca told one of his school-fellows that the Spanish deserved all the gold and silver in the country for introducing them and looking-glasses. The native mode of cutting the hair with flint and obsidian knives was tedious and painful.

But there are devices peculiar to American Indians which speak to the same effect. Early colonists on the Atlantic or Pacific coast, or inland, would be alive, as new colonists ever are, to native devices, and ready to adopt such as had advantages over their own, and such they would naturally send or take to their own people. Now, among others, there is one that could not have escaped the observation of even transient visitors or settlers, and one so novel, simple, and efficient that, if the knowledge of it ever reached Europe or Asia, it would certainly have been preserved to this day. I refer to the *Tepiti*, or Cassava press, as interesting an example of primeval ingenuity as sacred or profane writers have ascribed to oriental inventors.

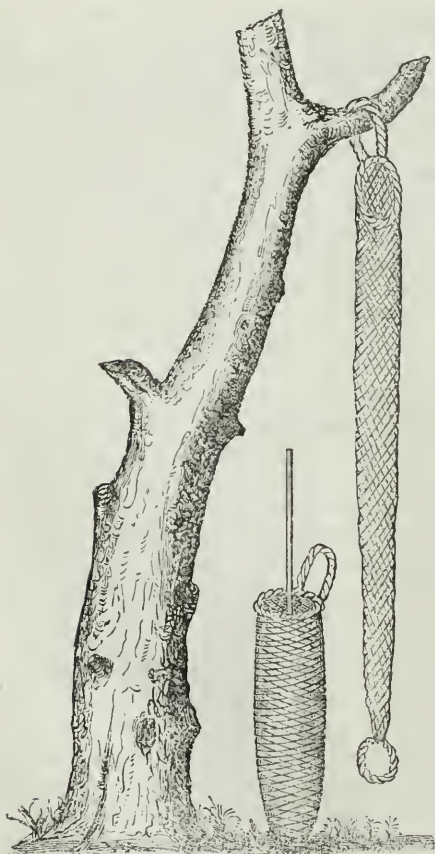
Were all the contrivances of untutored tribes collected together, they would present a greater range of research, and inventions more beautifully simple, than we are apt to imagine. Some are such as science is glad to adopt, many which she is slow to supersede, and others, as the boomerang, that she is puzzled to explain. Barbarian patriarchs of our species were the parents of the arts; spinning and weaving rose with them; elemental metallurgy and earthen ware are theirs. The chisel and drill, the hatchet and adze they gave us, and from them the most precious of primitive conceptions was received—the means of producing and using fire. In their condition they evinced as fine talents for invention as have their descendants under more favorable circumstances. With them every device was original, and the arts of civilization are, in the main, improvements on their suggestions,—expansions of their ideas. We build on a foundation they laid, and cultivate a field they began to plant.

Amid the furor attending modern inventions, primitive ones are neglected, much as letters are by those who have learned to read. We inherit the mechanical alphabet from barbarians, and, considering the times, places, and circumstances in and under which the elements of the world's machinery were disclosed, an account of their origin and early applications would form a brilliant chapter in the romance of history and of the first rude struggles of genius. If scholars can learn nothing from childrens' "first lessons," the wild man's horn book of inventions may be consulted with advantage by those who are in quest of new ideas or even new principles. The Tepiti, a very ancient contribution of some mechanical Cadmus of the tropics, is an example. Having had occasion recently to refer to it, I have thought, as illustrating a principle little known or used, a description of it might be usefully suggestive to inventors.

On their discovery the red race was found in possession of two chief elements of vegetable food; one the seeds of a grass, *maize*, the other the roots of a shrub, *cassava*. The first was cultivated in the temperate, the second in the warmer zones, and throughout the same parallels they are still prepared and used by the natives as by their ancestors immemorially. Every one knows how northern Indians pounded their corn in mortars, and how often, among other relics turned up by the plough, stone implements for that purpose occur. The treatment of the southern product was different. The mandioca, or cassava root, is a species of potato, resembling, in its long, irregular figure and dimensions, the sweet potato. It cuts like our Mercers, white, firm, watery, and somewhat fibrous. It is cultivated as extensively throughout Spanish and Portuguese America as maize is with us. Farina prepared from it resembles in appearance and qualities our Indian meal. It is "the bread of Brazil." There slaves live chiefly on it, and planters, merchants, and all classes have it always on their tables. In the process of converting the root into flour, a higher and more varied order of mechanical resource was displayed by primitive millers of the south than is revealed in the "corn-crackers" or "bread-pounders" of the north.

The root is first washed, scraped, and then grated to a pulp. This they do on a slab of wood prepared by smearing over one side with a thick gum, in which they insert a multitude of sharp particles of flint or granite broken up for the purpose. The gum hardens like stone and produces a rasp or grater that lasts a life time. On one of these a root is rubbed down in a moment, and when any required quantity is thus treated, in order to get rid of the poisonous water, the pulp is put into the Tepiti, a coarse, basket-like tube, made of thin splits of cane or bamboo, three-fourths of an inch wide and rather loosely interwoven. (See figure.)

A common size is five feet long, five to six inches diameter at the mouth or open end, and three or four at the bottom or closed one. A large loop, or a couple of strong withes, is formed at each end. When used, the first thing is to wet it if dry. The operator then grasps the edges



of the mouth with both hands, and, resting the bottom on the ground, throws the weight of his body on the basket till he has crushed it down to about half its previous length or height, and, consequently, swelled out its diameter. A smooth stick, like a broom-handle, is then introduced, the pulp put in and packed round it till the basket is filled. It is then suspended from a hook or the limb of a tree and a heavy stone or basket of stones fastened to the bottom, the weight of which stretches the tube till it becomes longer than at first. The capacity, of course, diminishes with the extension, and the contracting sides press the pulp against the unyielding stick and squeeze out the water. Instead of stones one end of a log of wood is inserted into the lower loop and loaded with a papoose or two, or anything else at hand, or the squaw herself puts a foot in the stirrup and serves as the weight.

Such is the Cassava press, an invention dating back to the earliest settlers of Central and South America, or coeval with their knowledge of the root. It was as

common among the Caribs of the Islands as it was and is with Indians on the Amazon and Orinoco, and throughout the vast regions from Mexico to the Plata. In Brazil there are those who prefer it to screw presses imported from Lisbon and Malaga at a cost from two to three hundred dollars. I purchased one at a venda, for sixteen cents, of the above dimensions, and for it the Indian manufacturer probably received only three or four, certainly not over five or six. It is used by planters on the Amazon for expressing oil from cantanha nuts.

If there is a current primitive invention evincing closer and happier reasoning out of common tracks, we know not where to look for it. Nor is that all; fabricated before metals or tools were known, Indians still bring it out of the woods with little but their hands to produce it. Were it proposed to compare the amount of originality and ingenuity in two aboriginal devices, representing the eastern and western hemispheres, I would select the Tepiti. Confront it with the analogous original one of the old world, the wine-press common throughout Egypt in her highest estate: a sack filled with grapes and twisted in contrary directions as washerwomen wring out wet linen. A stick was thrust through or attached to each end. They were turned by four men, two at each stick. Had the Tepiti ever been known there, it would most likely have been found figured with the foregoing at Thebes or Beni Hassan, and at Herculaneum or Pompeii with screw and wedge presses of the Romans.

The capacity of the basket decreasing as the length increases may not be instantly obvious to every one. Without reflection it might be supposed that extension in one direction would compensate for diminution in the other, that if elongation reduced the diminution one-half and at the same time doubled the length, the capacity would be little affected. The action and effect are, however, perceived by supposing the instrument made of a highly elastic material, india rubber, for example. It might then be stretched till the sides came together and formed a solid thread.

I am told the difference between a low and wide measure and a high and narrow one is not unknown, among others to proprietors of drinking saloons, as appears from the substitution of tall and tapered glasses for old Dutch-bottomed ones, over which they soar, that the change is a literal deduction from and a profitable application of the principle by which the cassava pulp is squeezed in the Tepiti. Admitting this, it is but one of a thousand interesting instances of physical principles little known creeping almost imperceptibly into extended use. It shows how pecuniary interest makes men of different professions active, though unconscious, promoters and elucidators of them. It is the working of the same beneficent law which in the natural world "from seeming evil still educes good." Thus, cupidity, awake to new chemical and mechanical facts, and alert in applying them to every purpose that promises to pay, is an efficient diffuser of useful knowledge. Like the rapacious instinct in some of the lower tribes, it contributes to the general good, and, as with them too, its eagerness occasionally leads to disappointment and loss.

E.

*On the Decay of Gutta Percha and Caoutchouc.** By Prof. WILLIAM ALLEN MILLER, M. D., F. R. S.

From the London Artizan, December, 1865.

The inquiries to which this investigation has given rise have extended over many months, and have included a large number of analyses, but the results obtained may be stated in a small compass, as they are very definite. I have examined numerous samples of gutta percha cables, both injured and sound, which have been in use for several years, and I find in all cases that the deteriorated portions have undergone chemical change, and that change consists in a process of *oxidation*.

Whatever retards or prevents this oxidation, retards or prevents the decay of the gutta percha, some of the specimens which I examined being as good as new, though they had been manufactured and used electrically for years, whilst others in a few months had become brittle, rotten, and unserviceable. As the general result of these inquiries, I find that when the gutta percha has been completely submerged in water no injurious change has occurred, sea water appearing to be eminently adapted to the preservation of the gutta percha. On the other hand, alternate exposure to moisture and dryness, particularly if at the same time the sun's light has access, is rapidly destructive of the gutta percha, rendering it brittle, friable, and resinous in aspect and in chemical properties. A gradual absorption of oxygen takes place, and the gutta percha slowly increases in weight, becoming at the same time proportionately soluble in alcohol and in dilute solutions of the alkalies. In every instance, however, some portion of the gutta percha remained unchanged in composition.

My experiments have also been extended to the prolonged action of air, moisture, and light upon india rubber, and here also I find that these agents effect analogous changes, though somewhat less rapidly.

The caoutchouc, however, instead of becoming brittle, is converted into a glutinous mass, losing its elasticity, increasing in weight to a certain extent, and becoming partially soluble in alcohol and diluted alkaline liquids.

These deductions are made from the examination of a number of samples supplied to me partly by Captain Galton and Mr. L. Clark, including specimens of coated telegraphic wires suspended in air, specimens of submarine cables, specimens of wires sunk in the soil under various conditions, besides experiments instituted by myself upon the action of various agents upon gutta percha, and they include the results of an extended and well contrived series of experiments made at the works of the Electric Telegraph Company, under the direction of Mr. L. Clark.

I will here subjoin an abstract of the principal experimental details,

* A paper on this subject by Mr. Spiller having recently appeared, it has been thought that the Fellows might be interested in an official report made five years ago to the Joint Committee appointed by the Lords of the Committee of Privy Council for Trade and the Atlantic Telegraph Company, to inquire into the construction of submarine telegraph cables.—*Ed. Jour. Chem. Soc.*

and, for the convenience of reference, will arrange them under the following distinct heads :

1. Experiments upon pure gutta percha.
2. Experiments upon commercial gutta percha.
3. Experiments upon submerged cables.
4. Experiments upon decayed and damaged cables exposed in air and underground under various circumstances.
5. Experiments upon caoutchouc.
6. Experiments upon other compounds.

1. *Experiments on pure gutta*.—Pure gutta differs in some of its properties from the commercial gutta. I found on examining the whitest samples purified by Dr. Cattell, that it formed a porous milk-white mass, wholly soluble in benzol, in ether, in bi-sulphide of carbon, and in the ordinary solvents of gutta percha. It is a perfectly pure hydro-carbon, probably containing $C_{20}H_{30}$. I found it to consist of—

	Found.		$C_{20}H_{30}$.
Carbon, . . .	88.96	or	88.88
Hydrogen, . . .	11.04	"	11.12
	100.00	"	100.00

When exposed to a temperature of 212° it softens but does not liquefy; it loses a trace of moisture, and then gradually absorbs oxygen, becoming brown, brittle, and resinous in appearance. In one specimen the increase in weight amounted to 4.45 per cent. The oxidized portion is insoluble in benzol, which when digested on the brown mass dissolves out a quantity of unaltered gutta, which had been protected from oxidation by the coating of resin.

This resinous mass, when thus purified, was found to have been produced from the gutta percha by simple absorption of oxygen, the gutta having in one experiment absorbed more than a fourth its weight of oxygen from the atmosphere.

2. *Chemical experiments on commercial gutta percha*.—The gutta percha of commerce is not a pure proximate vegetable principle, but it consists chiefly of a hydro-carbon which may for brevity be termed *pure gutta*, or simply gutta, mixed with a product of its oxidation, which is in the form of a soft resin, amounting to about 15 per cent. in the best commercial samples.

The following is the composition of a piece of ordinary good commercial gutta percha, taken from a piece of new cable supplied to me by Mr. L. Clark :

Pure gutta, ...	79.70
Soft resin, ...	15.10
Vegetable fibre, ...	2.18
Moisture, ...	2.50
Ash, ...	0.52
	100.00

The moisture reported in this analysis is mechanically diffused through the mass of the gutta percha, and seems to have some influence upon its pliability and toughness. 100 parts of the commercial

sample, when dried at 212° till it ceased to lose weight, deducting the ashes, contained :

Carbon,	.	.	.	.	.	.	84.66
Hydrogen,	.	.	.	.	.	.	11.15
Oxygen,	.	.	.	.	.	.	4.19
							100.00

This gutta percha softens and liquefies by a heat of 212° . It is soluble, with the exception of a few flocculi of fibrous matter, in benzol, in bi-sulphide of carbon, and in ether. Alcohol dissolves none of the pure gutta, but extracts a portion of the soft resin. This resin is an oxidized compound, probably in a transitional condition to a higher stage of oxidation. I found it to consist of—

Carbon,	.	.	.	.	.	.	76.15
Hydrogen,	.	.	.	.	.	.	11.16
Oxygen,	.	.	.	.	.	.	12.69
							100.00

The true gutta was extracted nearly pure from this sample by dissolving it in benzol, filtering, and adding alcohol, when a coagulum of pure gutta was obtained, which was found to consist of—

Carbon,	.	.	.	.	.	.	87.22
Hydrogen,	.	.	.	.	.	.	12.04
Oxygen,	.	.	.	.	.	.	0.74
							100.00

The presence of the small quantity of oxygen in this case was due to a little of the resin which still adhered to the precipitated mass of gutta.

Commercial gutta percha may be preserved for months, and even years, with little change, either in water or in air, provided light be excluded. This I have found from my own experiments, and the results which I have myself obtained are confirmed by experiments made by Mr. Clark. The following are some of the most important of these experiments: 500 grs. of thin sheet gutta were exposed under various conditions at the end of last October at the Electric Cable Works. The various samples were examined on the 2d of July of this present year (1860).

1. In netting, exposed to sun and rain in open air.
2. In a bottle, open to the air and light but excluded from rain.
3. In a bottle, open to the air but excluded from light.
4. In fresh water, open to air and light.
5. In fresh water, open to air excluded from light.
6. In fresh water, excluded from air and light.
7. In sea water, exposed to air and light.
8. In sea water, excluded from light but exposed to air.
9. In sea water, excluding both light and air.

The specimens 4, 5, 6, 7, 8, and 9 were wholly unaltered, with the exception of a slight increase in weight, due to the absorption of water, which they lost again after exposure to the air for an hour or two. The tenacity and structure of the material did not appear to have undergone the slightest change.

No. 2, which had been folded up and introduced into a bottle, the mouth of which was open and inverted, had increased in weight from 500 grs. to 524·5 grs., or about 5 per cent., owing to absorption of oxygen from the air. The outer layers of the sheet, where exposed to light, were brittle and resinous in appearance, but the inner portion, which had been screened from light by the outer folds, was but little altered in texture or appearance.

On examining chemically a portion of the most brittle part, I found a large portion of it to have lost the composition of gutta, and to have become converted into a matter soluble in alcohol, 55 per cent. of the mass being in fact transformed into the resin already spoken of.

The sample No. 3, which had been kept in the dark, had experienced little or no change. It had only increased 2·5 grs. in weight, or 0·5 per cent., and when treated with alcohol gave up 7·4 per cent. of resinous matter to it.

These results agree with those which I made upon gutta percha which had been exposed to the light of day for the shorter period of two months. This specimen had become quite brittle, had increased in weight 3·6 per cent., and yielded 21·5 per cent. of resinous matter soluble in alcohol; whilst a piece of the same sheet kept in the dark had undergone no sensible change.

Samples of sheet gutta percha were also subjected in November last to the action of the following liquids and exposed to diffused daylight:

A. Boiled linseed oil.		C. Stockholm tar.
B. Linseed oil not boiled.		D. Coal tar.

When examined on the 4th of August, 1860, or at the end of nine months, these liquids were found not to have exerted any perceptible solvent action upon the gutta, which retained its texture and tenacity in all those portions which had been fairly submerged in the liquid and protected from the light and atmospheric air; but in those portions which had projected into the atmospheric air contained in the jar, where it was also exposed to the effects of diffused day-light, the texture had become rotten, and the material more or less brittle and resinous.

All the liquids above-mentioned are calculated to exclude oxygen from the gutta percha, and thus they are enabled to exert a preservative influence upon it, without, however, in any degree softening or dissolving its texture. Hence they are likely to be highly valuable agents in coating the insulating material.

(To be continued.)

Furnace Slags.

From the London Mechanics' Magazine, September, 1865.

Dr. F. G. Finch read a paper "On the Utilization of Blast Furnace Slags." He said, within the last two or three years, by a process of slow cooling, a durable artificial stone had been produced at several iron works in France and Belgium, and was used for building purposes and as paving stones for roadways. The result had been satisfactory in

a pecuniary point of view. Having recently visited most of the places where the stone was produced, he would describe the plans adopted. The slag was allowed to run from the furnace in a fluid state into pits in the ground, eight or nine feet in diameter at the top, with sides sloping inwards to the bottom, the pits being three feet deep in the centre. The liquid hardened on the top, and the hardened mass rose as the pit filled. The furnaces were tapped every eight hours. The mass in the pits took nine or ten days to cool. It was quarried by means of large hammers and iron bars. The material thus obtained, except the crust on the top and a thin layer at the sides and bottom, was a hard, compact, crystalline stone, often resembling certain basalts. Of course, its quality depended on the nature and proportion of the materials with which the furnace was charged. That produced from cinder iron did not equal that produced in the manufacture of grey pig. The stone was found to have a high degree of resistance to crushing. It was largely used in France for paving, and was worked by masons into pieces of the form and size desired with facility, while the waste thus obtained was employed for macadamized roads. He had seen it where it had been laid down for three years. The French engineers spoke favorably of it, and the iron masters showed him proofs that, while this process got rid of a cumbersome material, it was itself a profitable branch of industry. The great consideration in England to such a manufacture would be the space it would require. With three tappings a day, each tapping filling one pit, and ten days for cooling, 30 pits would be needed, which would require a space of 2400 square feet. It was not often that so large a space could be made available at our iron works; but, on the other hand, it should be remembered that France was very deficient in stone suitable for paving.

Proc. Brit. Asso.

On the Hydraulic Properties of Magnesia. By M. H. STE. CLAIRE-DEVILLE.

From the Proceedings of the Academy of Sciences of Paris.

About seven years ago, M. Douy, an Engineer of the Salt-Spring Company of the North, sent me some magnesia obtained by calcining the chloride of magnesium. It was a product of the processes invented by M. Balard for the utilization of the mother-waters of the salt springs, put in practice in France and also at Strassfurt in Prussia, in mines from which there is at present extracted considerable quantities of the chlorides of magnesium and potassium, and of sulphate of soda.

This magnesia, which was anhydrous and in compact lumps, was left for several months in the running water under a hydrant in my chemical laboratory at the Normal School. It assumed a remarkable firmness, became hard enough to scratch marble, of which it had the density and tenacity, translucent in thin pieces like alabaster, and crystalline in geodes, which were formed in the interior of the mass. After six years of exposure to the air, this material is in no wise altered, and its analysis gave me the following results:

Water,	.	.	.	.	.	.	27.7
Carbonic acid,	.	.	.	.	.	.	8.3
Alumina and oxide of iron,	.	.	.	.	.	.	1.3
Magnesia,	.	.	.	.	.	.	57.1
Sand,	.	.	.	.	.	.	5.6
Total,	.	.	.	.	.	.	100.0

The small quantity of carbonic acid found in this material shows that it is essentially formed of a crystallized hydrate, and that this hydrate, like brucite, does not attract carbonic acid and form a carbonate.

To prove that this is the case, I prepared very pure magnesia by calcining the nitrate at a low red heat, and pulverized the mass finely enough to make with water a semi-plastic mass, which I allowed to remain for some weeks in boiled distilled water enclosed in a tube hermetically sealed.*

The magnesia gradually combined with the water and assumed a hardness and compactness comparable with those of my former specimens. It also became crystalline and translucent. After drying in air it had the following composition:

Water,	.	.	.	.	31.7	30.7
Magnesia,	.	.	.	.	68.3	69.3
Total,	.	.	.	.	100.0	100.0

It was, therefore, a simple hydrate of magnesia. I made with this substance, medals cast as with plaster, and they set under water, presenting the appearance of marble.†

The magnesia of M. Balard, when calcined at a bright red heat, has hydraulic properties, which show themselves with a wonderful rapidity and perfection. Calcined at a white heat for twelve hours, pulverized and made into a paste, it does not set unless it be left for several weeks in contact with the air, and even then it hardens slowly, so that its hydraulic properties appear to be almost lost.

A mixture of chalk, or of marble, and of magnesium pulverized, furnishes with water a slightly plastic paste, which moulds well and gives, after remaining some time in water, products of very great solidity. I intend to try this material for casting busts in artificial marble, the qualities of which may be very important if my expectations are fulfilled. All my experiments have been made heretofore with a mixture of equal parts of marble and magnesia.‡ Fontainebleau sandstone gives with

* If the pulverised magnesia be tightly packed at the bottom of the glass tube, and water poured on it, the tube will soon be broken by the formation of a compact hydrate of greater volume than that of the calcined magnesia.

† I speak here only of the magnesia obtained by calcining the chloride or the nitrate of magnesium. As to the light magnesia prepared by means of the hydrocarbonate, it gives on hydration a less tenacious talcose product, to which I shall refer again.

‡ M. Damour has published in the *Bulletin de la Société Géologique* (2d series, vol. iv., 1846) the analysis of a mineral, predazzite, composed like my artificial stones, of carbonate of lime and hydrate of magnesia. M. Damour considered this substance as formed by a mixture in which the carbonate of lime is cemented by the hydrate of magnesia. My experiments confirm manifestly this explanation. Predazzite is composed of carbonate of lime 63, hydrate of magnesia 35.1, foreign substances 11.9.

magnesia a product still more remarkable on account of the grain which it has and its strength.

Plaster of Paris mixed with magnesia undergoes alteration under water and diminishes its hydraulic properties.

My experiments on these mixtures suggested to me the idea of calcining, at a temperature of from 300° to 400° , (572° to 752° Fahr.,) dolomites tolerably rich in magnesia, to make them into paste with water and try them as cements. These materials differ from poor lime only in having been cooked at a temperature far below that of the kilns, and they have properties essentially differing from them. The dolomite treated at a low temperature set under water very rapidly, and gives a stone, the hardness of which is really extraordinary. The specimen which I have the honor to submit to the Academy was prepared with the dolomite which Messrs. Bell of New Castle, employ for making magnesia by the Pattinson process.

If the dolomite is heated more strongly, so that a little lime is formed in the mass, this lime does not yet interfere with the setting, but it separates in fine crystalline veins which are perfectly pure arragonite and free from magnesia. The crystals of this carbonate are perfectly visible under the lens and are all prismatic so as to leave no doubt as to their form. The complete absence of carbonate of magnesia from this material proves once more the correctness of my brother's observations upon the incompatibility of lime and magnesia when their compounds assume certain crystalline forms.

When dolomite is heated to redness the carbonate of lime is transformed into quick-lime, and the product entirely calcined, pulverized and made into a paste immediately loses all consistence in water.

In all these experiments the magnesia is the hydraulic material which cements, as it hydrates, the particles of intact carbonate of lime, exactly as in artificial mixtures of magnesia and marble, and makes a compact and homogeneous stone.

M. Paul Michelot has been kind enough, at my request, to expose all these magnesium materials to the action of the sea, at Boulogne, and up to this time, after a long trial, they have resisted. But these experiments are not yet finished, and I desire to leave this skilful engineer to publish his final results.

Other experiments have been tried, at my suggestion, upon feebly heated dolomites. According to the brief report which M. Michelot has been kind enough to make to me, they entirely confirm my results. The facts contained in this note prove the perfect hydraulic character of pure magnesia by the formation of a definite hydrate. They explain the successful attempts of M. Vicat to introduce magnesia into marine cements; and permit me to hope that by means of them the arts may utilize a substance which has been, thanks to the admirable processes of M. Balard, put at their disposal at a low price and in indefinite quantities.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, January 17th, 1866.

The meeting was called to order with the President, Wm. Sellers, in the chair.

The minutes of the last meeting were read and approved.

The minutes of the Board of Managers were reported, including the following donations to the library: From the Massachusetts Institute of Technology, Boston, Massachusetts; Charles Cologné, Esq., Washington, D.C.; Professor John F. Frazer and the American Philosophical Society, Philadelphia.

The Annual Report of the Board of Managers was then read and accepted.

The minutes of the Standing Committees were reported, and the Special Committee on experiments in steam expansion reported progress.

SECRETARY'S REPORT.

Mechanics.—In a paper read before the Institute of Mechanical Engineers, by Mr. David Greig, it is stated that the means of applying steam power to purposes of cultivation have been so far improved as to render this process practically successful under the conditions most favorable to its operation. The improvements which have in a marked manner contributed to this result are: 1st. The “clip-drum” for giving motion to the wire rope by which the cultivating implement is moved. In this apparatus the rope is seized, in passing over the drum, by self-adjusting clips, which grasp it firmly at either side, thus preventing it from being flattened, and giving it sufficient hold with one turn, where otherwise, four would be required. 2d. The use of steel wire rope, which possesses remarkable strength. 3d. An ingenious contrivance for taking up the slack and preventing the rope from dragging, which action was found to increase the resistance tenfold. 4th. The use of *strong* rather than *light* engines. The peculiar wedging action of the plowshare was found to be far more efficient than any produced by rotary cutters.

The Volta prize has been awarded to Fresnel for the invention of a new electric lamp, very superior in its structure to any hitherto used. The carbon points are not only caused to approach each other as they are consumed, but are also separated if they come too close, this action being accomplished by two clock movements, (tending to produce opposite motions,) one or other of which is liberated at a time by an escapement, controlled by an electro-magnet whose force varies with the quantity of the current passing, and is thus very sensitive to any change in the distance of the points.

A piece of apparatus was lately exhibited in England, invented by a Mr. Kirk, in which water was frozen by the expansion of previously condensed and cooled air.

In connexion with this statement, Mr. Coleman Sellers remarked: An apparatus of this kind was made in Cincinnati thirteen or fourteen

years ago, intended for New Orleans, and was put in successful operation. I was present at the time the experiments were made. The reservoir for air was very large, twelve feet long by forty-eight inches in diameter, made of heavy boiler plate. Air was forced into this by a beam engine. The air being forced into this vessel, the heat generated by the compression was allowed to pass off, and the air then allowed to expand in a vessel, where the freezing was accomplished, part of the force existing in the compressed air, however, being utilized in an intermediate cylinder. The greatest difficulty encountered was in making a boiler which would be air-tight at high pressures. The air leaked through the substance of the iron. By some means, however, possibly by coating with copper or tin, a thoroughly air-tight vessel was obtained.

It is stated that Carré's apparatus for obtaining cold by the use of ammonia has been applied with success to the extraction of a double chloride of magnesium and potassium from the mother liquor left in the salt pools in which sea-water has been evaporated at Montpellier, in the south of France.

An improvement in the Lenoir gas engine by M. Hugon is mentioned, which consists in an arrangement by which the explosive mixture in the cylinder is ignited by small gas jets, which are themselves relit in turn, when extinguished, by another. This obviates the numerous inconveniences and expenses arising from the use of a battery and induction coil, as in the original machine.

Clay for moulding may be rendered permanently moist, according to a writer in the *London Mechanics' Magazine*, by using a strong solution of chloride of calcium.

In a catalogue of apparatus by the famous French maker Salleron, presented to the Institute by that gentleman, and kindly forwarded, with other valuable and interesting matters, by Mr. James Swaim, we notice, among other things, the drawings and description of a very curious piece of apparatus, illustrating the action of the Giffard Injector. A cylindrical glass reservoir with metal ends, in one of which is an inward opening valve, is placed horizontally, with a small air-gun, supplied with air from the same reservoir, pointed exactly at the valve. The reservoir is charged by a condensing air-pump, the chamber of the gun receives its supply from this, a ball is placed in its barrel, and then it is discharged, whereupon the ball is driven against the valve which it opens, and enters the reservoir against a pressure exactly equal to that which caused its own motion.

Chemistry.—A new application of paraffin has been made by Dr. Stenhouse, of England. He mixed that substance with a few per cent. of linseed oil, and then saturates with this mixture canvas for tents or awnings and like materials, thus rendering them water-proof. Leather treated in a similar manner has great advantage when made into boots and shoes, as it is freed from the destructive action of alternate wetting and drying.

Mr. Barrett observes that sand paper will emit a phosphorescent light for some moments after a hydrogen flame had played upon it.

A new process for obtaining caustic soda is announced by Mr. A.

G. Hunter, of England. Sulphate of soda in solution is mixed with burned lime and subjected to great pressure, when, according to this gentleman, sulphate of lime will be formed and caustic soda left in solution.

Thalium has been found in notable amount, by Bunsen, in the water which has been used for washing the pyrites of Rammelsberg, at Juliusshutte, and by Professor Bischoff, of Lausanne, in an ore of manganese, which contains as much as one per cent. of thalium.

The editor of the *British Journal of Photography* speaks with high approbation of the rectified wood spirits or methylic alcohol as a solvent for gun-cotton, in place of the mixture of alcohol and ether now used in the preparation of photographic collodion.

Gun-cotton is being largely used in California and Nevada. At the new Almaden Quicksilver Mines it is very extensively employed. Mr. C. E. Hawley, the chief engineer, says that its most valuable property is its freedom from smoke, which leads to a great saving of time in the works, as the miners are not obliged to wait for some time that the smoke may clear away after firing blasts, as is the case with gunpowder.

A brass, composed of 60 parts copper, 38 zinc, and 2 of iron, is said to bear forging at a red heat, and to resist a breaking strain of 27 tons per square inch.

A very curious experiment, illustrating the manner in which platinum will cause the formation of certain chemical compounds by its mere presence, is published by the German chemist, K. Kraut. Oxygen gas is caused to pass in bubbles through some aqua-ammonia contained in a flask, in which is hung a spiral of platinum wire heated red-hot. Under these circumstances heavy fumes of nitrite of ammonia will be formed, developing heat enough to keep the wire red so long as the flow of oxygen and supply of ammonia from the solution lasts.

(This experiment was here performed by the Secretary.)

Mitscherlich, at the conclusion of a paper in which he recounts the results of a long and elaborate study of the metalloids with the spectroscope, states his opinion to be that all these bodies are not elements but compounds.

To amalgamate dirty zinc plates for a galvanic battery, set them in a dish with 3 ozs. common muriate acid, 1 drachm of a saturated solution of corrosive sublimate, and $\frac{1}{2}$ oz. of mercury, and smear the mercury over the plate.

The Commissioners of the Belgian government have reported favorably as to the efficiency and inoffensiveness of a new gunpowder for blasting, manufactured by Messrs. Schäffer & Budenberg, of Buckau, Magdeburg, and Manchester.

In the last number of the *Philadelphia Photographer* is a very interesting article On the Solar Spectrum, by Professor Rood of New York. Among other facts noticed is this curious one, that blue and yellow, mingled by rapid motion, as this disk turned by the whirling machine, will not produce green, as is commonly supposed, but flesh color. (This fact was demonstrated by experiment.)

A very simple and ingenious method of demonstrating some of the actions concerned in wave motions, owes its development to this same gentleman. Two glass slides, capable of moving in the ordinary magic lantern, are covered with black varnish. On one of these a series of equal and equidistant vertical lines are scraped clear, while upon the other a single horizontal wave line is in like manner produced. These plates being placed together in the lantern, a wave line will be shown on the screen made up of detached blocks. If, now, the slide having the undulating line on it be moved horizontally, a progressive motion of the wave will be shown without any progression of the individual particles.

(This arrangement was then exhibited.)

A glass photograph of a part of the solar spectrum, made by Mr. L. M. Rutherford of New York, was then shown in the lantern, and its relative position in the spectrum described; the fact also being noted that these photographs showed twice as many lines as were to be found in the elaborate plates of Kirchhoff.

Professor Fairman Rogers then presented to the meeting a photograph on glass of the moon, made also by Mr. L. M. Rutherford of New York, and remarked, in connexion with this subject, that Mr. Rutherford had succeeded in producing more perfect pictures of the moon than any other experimenter, either in this country or abroad. These were obtained by the use of a telescope expressly arranged for this purpose, whose lenses had been corrected for the more refrangible or actinic rays by Mr. Rutherford himself. The correction was accomplished by a process of local grinding; constant experiments being made by means of photography to determine from time to time what effect was being produced upon and what was yet needed by the lens. The greatest credit is due to Mr. Rutherford for the time and care, as well as skill, which he has devoted to the construction of this instrument, and to its use.

At the conclusion of these remarks the Tellers of the Annual Election for Officers, Managers, and Auditor, to fill the vacancies of those whose term of office has expired, reported the result as follows:

President, William Sellers.
Vice President, (three years,) John H. Towne.
Secretary, Henry Morton.
Treasurer, Frederick Fraley.

MANAGERS.

(For one year.)
William B. Bement.
Edward Y. Townsend.

(For two years.)
John Rice.

(For three years.)
Washington Jones.
Charles H. Cramp.
Pliny E. Chase.
Charles S. Close.

James S. Whitney.
James Dougherty.
J. Vaughan Merrick.
Robert C. Cornelius.

AUDITOR.

Samuel Mason.

The meeting was then, on motion, adjourned.

H. MORTON, *Secretary*.

*Annual Report of the Board of Managers of the Franklin Institute
for the Year 1865.*

In accordance with the By-Laws, the Board of Managers presents its Annual Report of the condition of the affairs of the Institute.

Soon after the beginning of the last year, an examination was made of the present Institute building, and the advantages and drawbacks attending a change of location were fully discussed. From the considerations thus made apparent, it was determined to execute extensive alterations and repairs, by which the present building might be rendered adequate to the purposes of the Institute, and attractive to those whom it was designed to accommodate. The execution of these alterations and improvements was placed in the charge of a committee, and with the beginning of the summer, when the building was less used than at other seasons, this work was commenced.

Notwithstanding the unprecedented difficulty in securing skilled labor which has marked the last season, these improvements have progressed in a satisfactory manner, and may be now said to approach completion, and have cost about \$7000. The work accomplished may be briefly expressed as follows:

A substantial and permanent slate roof has been put upon the whole building. The library and reading room has been enlarged so as to afford *additional* case room nearly equal to its whole original capacity. This change was demanded by the condition of the books, which were placed two deep in nearly all the cases, with additional crowding, which rendered any complete systematic arrangement out of the question. Large additions of new and important works have been made to the contents of the library, and the whole arranged in a convenient and accessible manner. The reading room and adjacent offices have been entirely refurnished, and rendered not only comfortable but highly attractive in their appearance and accommodations.

The lecture room has received most extensive alterations; each of the ascending platforms constituting the floor surface have been widened to secure comfort to the audience, and furnished with cane-seated chairs in place of the wooden benches formerly in use. A new lecture table, containing a large leaden pneumatic cistern properly furnished with inlet and outlet pipes, has likewise been added, and the space in rear of this increased to a depth of twenty feet, by which means optical experiments and illustrations of other subjects by optical apparatus may be developed with a facility and success equalled nowhere in this city. The whole arrangement for lighting this room has been reconstructed and proves itself both efficient and admirably under control. The laboratories adjoining the lecture room have been thoroughly repaired, furnished with new cases, with gas and water supply, and with an evaporating closet so as to answer efficiently to the demands of modern experimentation.

Lastly, the cellars of the building have been cleaned, opened, and repaired, and supplied with two furnaces of the most improved construction for heating the lecture and reading rooms.

By the report of the Treasurer it will be seen that the receipts and payments during the past year have been as follows:

Balance in the Treasury, January 1, 1865,	\$ 310 91
Receipts during the year,	39631 79
	39942 70
The payments have been—	38940 08
Leaving a balance in the Treasury, January 1, 1866, of—	\$ 1002 62

The indebtedness of the Institute is—

Amount of 5 per cent. loan,	\$ 12250 00
Interest due thereon,	4825 00
Temporary loan,	2500 00
	\$ 19075 00

Annual interest payable on 5 per cent loan,	612 50
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The number of life members now on our list is 616, and of contributing members in good standing 629, to which should be added 58 holders of stock of the second class, and 30 holders of 10 or more shares of the first class, who are not also life members, making the total number of members 1433.

The number of new members elected during the year is—	122
Of stockholders having members' privileges,	88
Total,	210
Members resigned,	59
“ died,	34
	93

Leaving a total gain during the year of—	117
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It is to be recommended to all the members and friends of the Institute to secure, if possible, the disposal of the entire stock of the Institute, by which its permanent success would be placed upon a secure basis. It is also to be remembered by holders of stock, that they not only enjoy the advantages of the Institute at a cheaper rate than members, but have beside an ownership in the Institute. The holder of ten shares enjoys likewise all the privileges of membership, without the payment of any annual fee, and may besides bequeath this privilege to his survivors or assign it to another.

WILLIAM SELLERS, *President.*

A Comparison of some of the Meteorological Phenomena of DECEMBER, 1865, with those of DECEMBER, 1864, and of the same month for FIFTEEN years, at Philadelphia, Pa. Barometer 60 feet above mean tide in the Delaware River. Latitude $39^{\circ} 57\frac{1}{2}'$ N.; Longitude $75^{\circ} 11\frac{1}{4}'$ W. from Greenwich. By J. A. KIRKPATRICK, A. M.

	December, 1865.	December, 1864.	December, for 15 years.
Thermometer—Highest—degree, .	63.00°	59.00°	71.00°
“ date, .	27th.	7th.	2d, '59.
Warmest day—mean,	55.33	52.33	62.80
“ date, .	4th.	3d.	2d, '59.
Lowest—degree, .	17.00	12.00	4.50
“ date, .	15th.	12th.	19th, '56.
Coldest day—mean,	21.67	19.67	11.00
“ date, .	15th.	12th.	18th, '56.
Mean daily oscillation,	11.23	9.83	12.11
“ “ range, .	6.85	7.37	6.48
Means at 7 A. M., .	35.34	32.92	32.03
“ 2 P. M., .	40.82	38.58	39.31
“ 9 P. M., .	36.95	35.95	34.84
“ for the month,	37.70	35.82	35.39
Barometer—Highest—inches, .	30.424 ins.	30.411 ins.	30.678 ins.
“ date, .	23d.	9th.	18th, '56.
Greatest mean daily press.	30.399	30.362	30.611
“ date, .	23d.	9th.	18th, '56.
Lowest—inches, .	29.403	29.071	28.946
“ date, .	21st.	21st.	9th, '55.
Least mean daily press.,	29.535	29.275	29.175
“ date, .	1st.	21st.	9th, '55.
Mean daily range, .	0.206	0.265	0.215
Means at 7 A. M., .	29.945	29.801	29.950
“ 2 P. M., .	29.899	29.730	29.907
“ 9 P. M., .	29.946	29.782	29.936
“ for the month, .	29.930	29.771	29.931
Force of Vapor—Greatest—inches,	0.509 in.	0.438 in.	0.551 in.
“ date, .	27th.	7th.	2d, '59.
Least—inches, .	.068	.052	.025
“ date, .	22d.	12th.	18th, '56.
Means at 7 A. M., .	.177	.152	.146
“ 2 P. M., .	.180	.161	.168
“ 9 P. M., .	.182	.169	.157
“ for the month,	.180	.161	.157
Relative Humidity—Greatest—per ct.,	97.0 per ct.	92.0 per ct.	100.0 per ct.
“ date, .	27th.	2d.	often.
Least—per ct.,	33.0	26.0	23.0
“ date, .	5th.	1st.	15th, '61.
Means at 7 A. M.,	80.7	77.3	77.4
“ 2 P. M.,	64.3	64.8	65.2
“ 9 P. M.,	76.7	74.8	75.1
“ for the month	73.9	72.3	72.6
Clouds—Number of clear days,* .	6	3	8.5
“ “ cloudy days, .	25	28	22.5
“ Means of sky cov'd at 7 A. M.,	74.8 per ct.	73.2 per ct.	64.7 per ct.
“ “ “ 2 P. M.,	61.6	77.7	63.7
“ “ “ 9 P. M.,	60.0	77.7	49.1
“ “ “ for the month	65.5	76.2	59.2
Rain and melted snow—Amount,	5.677 ins.	4.754 ins.	3.842 ins.
No. of days on which rain or snow fell,	12	19	10.7
Prevailing Winds—Times in 100,)	N68°27'W .239	S72°54'W .158	N62°39'W .268

* Sky one-third or less covered at the hours of observation.

A Comparison of some of the Meteorological Phenomena of the YEAR 1865, with those of 1864, and of the last FOURTEEN years, at Philadelphia, Pa. Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½' N.; Longitude 75° 11¼' W. from Greenwich. By J. A. KIRKPATRICK, A. M.

	1865.	1864.	14 years.
Thermometer—Highest—degree, . .	97·00°	96·00°	100·50°
“ date, ...	July 7th.	June 26th.	July 21st '54
Warmest day—mean, ...	87·83	89·67	91·30
“ “ date, ...	July 28th.	June 26th.	July 21st '54
Lowest—degree, ...	3·50	4·00	—5·50
“ date, ...	Feb. 13th.	Feb. 17th.	Jan. 23d '57
Coldest day—mean, ...	12·00	7·00	—1·00
“ “ date, ...	Feb. 13th.	Feb. 17th.	Jan. 9th '56
Mean daily oscillation, ...	12·40	13·79	14·85
“ “ range, ...	5·52	5·27	5·53
Means at 7 A. M., ...	52·10	50·40	49·93
“ 2 P. M., ...	60·47	59·66	59·92
“ 9 P. M., ...	54·74	53·75	53·30
“ for the year, ...	55·77	54·60	54·38
Barometer—Highest—inches, . . .	30·424 ins.	30·411 ins.	30·704 ins.
“ date, ...	Dec. 23d.	Dec. 9th.	Jan. 28th '53
Greatest mean daily press., . .	30·399	30·362	30·611
“ date, ...	Dec. 23d.	Dec. 9th.	Dec. 18th '56
Lowest—inches, ...	29·141	29·071	28·884
“ date, ...	Jan. 7th.	Dec. 21st.	Ap. 21st '52
Least mean daily press., ...	29·226	29·150	28·959
“ date, ...	Oct. 19th.	Nov. 4th.	Ap. 21st '52
Mean daily range, ...	0·152	0·152	0·155
Means at 7 A. M., ...	29·852	29·772	29·878
“ 2 P. M., ...	29·811	29·730	29·838
“ 9 P. M., ...	29·846	29·775	29·865
“ for the year, ...	29·836	29·759	29·860
Force of Vapor—Greatest—inches, .	0·917 in.	0·895 in.	1·059 in.
“ date, ...	July 25th.	Aug. 2d.	June 30th '55
Least—inches, ...	·044	·022	·013
“ date, ...	Feb. 13th.	Feb. 17th.	Feb. 6th '55
Means at 7 A. M., ...	·348	·314	·325
“ 2 P. M., ...	·361	·321	·340
“ 9 P. M., ...	·364	·338	·345
“ for the year, ...	·358	·324	·337
Relative Humidity—Greatest—per et.,	100·0 per et.	100·0 per et.	100·0 per et.
“ date, ...	Feb. 23d.	Jan. 18th.	often.
Least—per et., ...	23·0	18·0	13·0
“ date, ...	April 24th.	Mar. 9, Ap. 7	Ap. 13th '52
Means at 7 A. M., ...	73·9	72·0	75·5
“ 2 P. M., ...	57·7	53·9	57·2
“ 9 P. M., ...	70·9	68·9	71·9
“ for the year, ...	67·5	64·9	68·2
Clouds—Number of clear days,* . .	101	94	108
“ cloudy days, ...	264	272	257
Means of sky cov'd at 7 A. M., . .	62·3 per et.	61·8 per et.	60·1 per et.
“ “ “ 2 P. M., ...	62·7	66·6	60·9
“ “ “ 9 P. M., ...	45·9	52·4	45·8
“ “ “ for the year, ...	57·0	60·2	55·6
Rain and melted snow—Amount, . .	53·637 ins.	46·730 ins.	46·022 ins.
No. of days on which rain or snow fell,	119	128	127
Prevailing Winds—Times in 1000,	s89°52'w·213	s82°22'w·220	s76°38'w·206

* Sky one-third or less covered at the hours of observation.

A General Abstract of the Meteorological Observations made at Philadelphia during the year 1865.—By Professor JAMES A. KIRKPATRICK.
Latitude 39° 57½' N. Longitude, 75° 11¼' W. from Greenwich. Height of barometer fount, sixty feet above mean tide in the Delaware River.

1865. MONTHS.	Thermometer.					Barometer.							Dew point.					
	Maximum.	Minimum.	Range.		Mean daily.	Means.			Lowest.	Range.		Means.			Means.		Average	
			Monthly.	Mean daily.		7 A. M.	2 P. M.	9 P. M.		7 A. M.	2 P. M.	9 P. M.	Average					
	°	°	°	°	°	Inch.	°	°	Inch.	Inch.	Inch.	Inch.	°	°	°	°	°	°
January,	51	6	45	7.14	11.90	22.85	29.90	26.85	30.315	29.141	1.174	.234	29.843	29.795	29.828	29.822	18.05	19.32
February,	56	3½	52½	5.97	11.34	28.45	36.20	32.44	30.322	29.256	1.066	.205	29.872	29.849	29.875	29.865	21.63	23.17
March,	76	24	52	6.72	13.97	42.03	52.40	46.16	30.210	29.185	1.025	.188	29.825	29.777	29.826	29.809	33.65	34.65
April,	79	40	39	5.99	14.33	51.25	62.03	54.48	30.265	29.404	.861	.172	29.897	29.844	29.889	29.877	40.13	41.55
May,	84	46	38	6.66	13.81	59.87	68.91	61.39	30.147	29.405	.742	.126	29.742	29.708	29.740	29.73	50.27	50.99
June,	93	61	32	4.52	13.23	73.79	83.28	74.73	30.069	29.589	.480	.081	29.854	29.821	29.841	29.839	64.89	65.76
July,	97	63	34	4.44	12.13	74.76	83.44	76.66	30.141	29.537	.604	.089	29.847	29.814	29.847	29.836	64.06	64.27
August,	91	58	33	3.29	12.13	72.10	81.02	74.56	30.141	29.540	.601	.089	29.847	29.814	29.847	29.836	62.21	63.17
September	89	49	40	4.81	11.90	70.73	77.85	73.42	30.225	29.583	.642	.169	29.950	29.888	29.933	29.924	63.25	63.58
October,	78	37	41	5.13	11.23	52.55	60.15	54.85	30.225	29.155	1.070	.171	29.778	29.746	29.786	29.770	42.98	43.52
November	66	26	40	4.73	11.63	41.43	49.63	44.45	30.405	29.395	1.010	.156	29.901	29.837	29.877	29.872	33.77	34.65
December,	63	17	46	6.85	11.23	35.34	40.82	36.95	30.424	29.433	1.021	.206	29.945	29.899	29.946	29.930	29.91	29.70
Annual means,	97	3½	93½	5.52	12.40	52.10	60.47	54.74	30.424	29.141	1.283	.152	29.852	29.811	29.846	29.836	43.73	44.48
Winter,	59	2½	55½	6.83	11.02	28.07	34.89	31.75	30.411	29.071	1.340	.255	29.839	29.791	29.828	29.819	22.00	23.48
Spring,	84	24	60	6.44	14.04	51.05	61.11	54.01	30.265	29.185	1.080	.162	29.821	29.776	29.818	29.805	41.35	42.75
Summer,	97	58	39	4.08	12.50	73.55	82.58	75.32	30.141	29.537	.604	.086	29.822	29.796	29.820	29.813	63.72	64.47
Autumn,	89	26	63	4.89	11.62	54.90	62.54	57.57	30.405	29.155	1.250	.145	29.876	29.824	29.865	29.855	46.67	47.78
Means 14 years,	100½	—5½	106	5.53	14.85	49.93	59.92	53.30	30.704	28.884	1.820	.155	29.878	29.838	29.865	29.867		43.36

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FEBRUARY, 1866.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Papers on Hydraulic Engineering. By SAMUEL McELROY, C.E.

No. 6.—*On the Irrigation of the Valley of Chimbote, Peru.*

The traveler from Panama to Callao, the chief port of Peru, on the South American coast, (from May to November,) after leaving the luxuriant vegetation of the Isthmus and the tropical abundance of Ecuador, is surprised and disappointed to find a rocky and forbidding coast for about eight hundred miles of his voyage, and to meet a continual head-wind and the cold Humboldt current which flows from Cape Horn, with the discomforts of a short, uneasy sea and a chilly temperature. Having started with some fear of the effects of a tropical sun, it is strange to meet a temperature much below a New Yorker's summer experience, and to feel the need of an overcoat on deck in latitudes scarcely ten degrees south of the equator. With historical knowledge of the agricultural wealth and fertility of ancient Peru, he is also somewhat unprepared to coast along vast ranges of volcanic hills, and to see the restless surf wash against leagues on leagues of barren and desolate trap-dykes and islands inhabited only by seals and sea-fowls, with the silent and gloomy grandeur of the Cordilleras in the background, barely eighty miles distant, with slopes, peaks, and rough outlines often vividly distinct in the sunlight.

He finds, however, with opportunities for inquiry and closer observation, that the forbidding line of the coast is frequently broken by the valleys of streams flowing from the mountains to the sea, generally into spacious bays and indentations; and that the cultivated parts of the country are confined to these valleys. He also finds that rain-

storms are unknown in this region, and that artificial irrigation is the only process which can be relied on for agricultural purposes. Still further, he is told that few of the mountain streams really reach the coast except at intervals of several years, when fed by an excess of supply, and artificial irrigation, in many localities on the coast, is therefore precarious and uncertain, while always costly and laborious; but, under a law of compensation which nature never neglects, he finds that under adequate irrigation, so great is the influence of the climate and the strength of the soil, that its productiveness in number, certainty, and richness of crops is in wonderful excess of regions apparently better favored.

Having had occasion, during the past summer, to make examination of one of the great valleys of this coast, with a view to its irrigation from one of the chief rivers of Peru, in a district which abounds with evidences of skill of a race which ceased to live and work over four hundred years ago, I have thought a notice of the location, climate, irrigation, productiveness, and methods of improvement would present several features of general professional interest.

The valley of Chimbote is situated in the district of Santa, about 200 miles north of Callao, in south latitude $9^{\circ} 15' 38''$, and longitude $78^{\circ} 32' 51''$. It is reached from Lima and Callao by the coast steamers of the English line, running about six times per month, which accomplish the distance, including their stops at various ports, in about forty-eight hours, landing at the port of Santa.

It is bounded on the north by the Chimbote Mountain and its Colorado (red) Range, which separate it from the valley of Santa. On the east it has a range of granite and clay hills which separate it in part from the valley of the river Seco, (dry.) On the south it has a narrow colorada range, which separates it from the valley of Nepenia. It fronts on two large bays admirably adapted to commercial uses as to depth of water, safe anchorage, and easy entrance, and abounding in fish and aquatic birds; of these the Bay of Ferrol is on the north and the Bay of Samanco on the south, separated from each other by a sand spit, with bold head-lands and islands on the sea-front. Ferrol Bay is about eight miles long by four wide, and Samanco Bay eight miles long by five wide. The extreme length of the valley is about sixteen miles, the width of the pampa, or plain, from the bays easterly being about four and one-half miles, in which distance it rises about 100 feet to the level of irrigation. The area which can be irrigated is about 51,000 acres.

The valley of Nepenia, situated on the south, contains considerable population, with the villages of Nepenia and Samanco, and several productive estates; but its fertility is restricted by want of water in the river, which does not flow regularly, or more than once in three or four years. This is also the case with the river Chimbote, a branch of the river Seco, which flows into Ferrol Bay on the northerly side of the valley. The valley of the river Seco, which runs easterly to the foot of the Cordillera Range about 50 miles, contains several villages and haciendas, (estates,) a large amount of stunted trees, valuable beds

of limestone, and abundance of fruit at Lachramarca and Santana. This river, when it flows as far as the coast, runs in part into the valley of Santa on its southerly border. The valley of Santa, fronting on the bay of that name, contains the ancient city of Santa, considerable population, with several very productive haciendas, and is watered by the river Santa, flowing from the Cordilleras with a powerful current and volume, not much affected by the seasons, and having a rapid fall throughout its course.

The Santa river formed the dividing line between the divisions of Peru and Quito in the days of the Incas who immediately preceded the Spanish invaders, and its valley was the scene of the great battle between the rival Incas, which occurred before Pizarro's landing. In riding over the country on surveys it was common to find skeletons and skulls in good preservation, and specially remarked that the teeth of the latter were sound as if pertaining to men prematurely dead, and probably to victims of this civil contest. On the bold hills and on the plains numerous structures yet remain in admirable preservation, as fortresses and temples, built of solid clay walls, with terraces, court yards, walled avenues, and gardens, and exhibiting evidences of great population and of great progress in arts of construction, horticulture, and defence. Other relics from the graves of these people, in cotton cloths, copper work, and pottery work, show great progress in some branches of art. On one side of the lower valley of the river Seco a large ruin exists at a high elevation, from the front of which a set of terraced gardens yet stand in good preservation, with their branch canals for irrigation, fed from the main aqueduct herein described.

The *climate* of this region is remarkably salubrious and favorable to agriculture. From April to November (the winter season) the daily temperature ranges between 67° and 75° Fahrenheit from midnight to noon, and from December to March there is an increase of about 8° at noon, with great uniformity from day to day. No rain-storms occur, but in the winter season, in the early morning, a light shower or rainy mist is common, the rest of the day being clear, with heavy dews at night. A sea-breeze springs up about one and tempers the noon heat. The proximity of the mountain ranges on the east, with the southerly trade-wind and cool Humboldt current of the coast, entirely modify and control the climate, so as to render it peculiarly agreeable to residents and favorable to vegetation. The local scenery is also highly picturesque in mountain backgrounds, fertile valleys, beautiful and tranquil bays, and the bold head-lands and islands of the coast. The atmosphere is very clear and dry, exerting a singularly preservative effect on building materials, animal substances, and otherwise, greatly to the comfort and health of the inhabitants.

Artificial irrigation is required here from the want of rain, and, when supplied, possesses several advantages of operation from the superior regularity of supply and its management.

For the valley of Chimbote the plan of irrigation is simple, being, in fact, a restoration of the great Peruvian canal, which formerly distributed the water from the Santa River over the entire area. This

canal, which has stood not less than five hundred years, was originally about thirty miles long, with a prism of various dimensions at different points, which I propose to reform for an average depth of four feet, and width at the top angles of eighteen feet. It was formed chiefly in the tenacious clay of the locality, protected with a growth of cane, and, notwithstanding a sharp fall of about five and a half feet per mile, which presupposes a rapid current, it stands, as a whole, in admirable preservation. For about sixteen miles in length it is constructed on a difficult location, chiefly along the steep slopes of granite and trap-rock hills, and at a high level above the valley of the Santa River. In some cases the rocks have been excavated by metallic tools or by fire process for part of the prism, but generally the canal bank is formed with a solid puddled wall of clay and stone, sometimes to a height of one hundred feet above its base, with steep slopes, about one to one, sometimes less, and with an amount of labor and an evidence of engineering judgment which testifies in strong terms of the enterprise and civilization of those long departed builders. While the line generally follows the hills, no hesitation is shown in taking advantage of occasional embankments in crossing valleys. One of these, across the valley of the river Seco, was about 1800 feet long and about 42 feet high, and in the next valley the embankment exceeds a mile in length, being curved to suit the ground and avoid extra work. Secondary canals also occur, adapted to special locations; and the intermediate drains, by which the valley below these embankments was originally irrigated, yet remain in all their special details of arrangement, as when the agencies of destruction swept away their constructors. Every step here is among monuments of past skill and taste of no common or modern local rank, and an engineer relearns the common professional lesson, that his calling was magnified in the by-gone ages rather than the present, where "the things which are not teach those which are."

We have observed that many rivers of Peru fail to reach the coast except in extraordinary seasons. This is to be accounted for partly by the absorption of their wide channel beds, but the chief reason is apparent when one has crossed the Cordillera. In the mule tracks which follow the valleys and mountain gorges on the western slope, as in the wild valleys between the Cordillera and the Andes, one cannot but be struck with the care which has been taken to secure even the first outburst of the head sources of the streams, and lead them off, often for many circuitous miles of expensive canals, for purposes of irrigation. In this way, chiefly, the coast is deprived of its natural supply, and without remedy, and the fact furnishes a powerful commentary on the patience and industry of the people, and the productiveness of lands which otherwise would be worthless. After witnessing these primitive works, and after riding more than twenty miles in a line, over the valley of the rivers Seco and Chimbote, now a desolate, open pampa, once teeming with all the luxuriance of the earth, and a vast population, one fords the swift and wide current of the river Santa, feeling a painful consciousness of the wastefulness of the constant and unappropriated stream, whose drops might be more precious than the golden sands of African fountains.

The work of irrigation over this valley is much facilitated by its peculiar formation, as an elongated parallelogram, with considerable seaward slope from the line of water supply. Various productions require various irrigations. Rice needs flooding, while cotton, cochineal, cactus, sugar cane, and other plants require special irrigations eight or ten times per year; and with the regular descent to the bays from the main aqueduct, the intermediate irrigation may be easily accomplished and with great economy of water, while ample power is furnished for the rice mills, cotton gins and presses, and other machinery.

The quantity of supply is assumed at 150 cubic feet of water per acre per day, as a sufficient amount for agricultural use, mills, and waste, and was determined from measurements of the supply of the several canals to the valley of Santa. A draft of 60,000,000 gallons per day will not seriously affect the volume of the Santa River. This supply is equivalent to about one inch in depth of water per working day of ten hours over this large area.

The cost of repairing this old canal is estimated at \$185,000, including an item of \$45,000 for 150 Chinese laborers, who are preferred, for transfer to cultivation, on the aqueduct completion, the work being estimated to occupy one year. Under the present system in Peru, coolies are much used, being employed under a contract for eight years service. They are paid four dollars a month for their labor, are fed, and have two suits of clothes annually, and they generally prove industrious, sober, good-tempered, and apt workmen, well adapted to the climate and the locality. About 160 are now employed on the hacienda of the Puente at Santa, and seem entirely content with their position. They are quick to learn, acquiring considerable Spanish in three months, and valuable assistants about machinery and mills. The native peons of the back country may be had in abundance at a cost of about sixty cents per day, and have many valuable qualities, being healthy, industrious, and docile, but are less reliable than the Chinese for steady service, and much more improvident.

When this aqueduct is restored to use it will control the hacienda of the Rinconada, and that of the Puente in the valley of the Santa, the pampa of the river Seco, and the great valley of Chimbote. Of these, the first two are irrigated by lower and independent aqueducts, and cover an extent of about 7500 acres, of which about 3500 are now under cultivation. The pampa of the river Seco, containing about 4000 acres, belongs to the Puente and joins the Chimbote Valley. The total area of pampa, from which valuable proceeds can be realized by this supply of water, is about 55,000 acres, and if ever restored, even in part, to the luxuriance of the days of the royal Incas, it will present a scene of agricultural beauty and wealth of no ordinary character and interest, and maintain a large population.

The productions of this locality are cochineal, cotton, silk, rice and other grain, sugar cane, fruit, grapes, horses, cattle, limestone, coal, and guano, salt, &c. The Cordillera Range, immediately eastward, is rich in mines of various kinds.

The cochineal bugs, which feed on the common cactus plant, abound

here of the most valuable species, and are easily raised and gathered. From its hardy nature this plant needs very little care and thrives abundantly, its leaves averaging about one pound of bugs per year per plant, with about 1000 plants per acre, which require irrigation several times a year, with occasional pruning. The cochineal is gathered by hand, a Chinaman usually collecting twenty to twenty-five pounds per day. It is then dried and cured by moderate heat, assorted, and packed for market. Recent quotations at Lima were \$1.25 per pound, currency, or \$1.00 hard money. A production of this valuable character and yield, always in demand at high prices, from so hardy a plant, which has a life of three or four years, being about \$1000 per acre, furnishes a sufficient argument for its encouragement.

This region proves admirably adapted to the production of cotton, which was a common article of manufacture among the ancient Peruvians, as appears by the well preserved dresses found in their graves. Various kinds of seeds have been imported and tested, the Sea Island, Indian, Egyptian, and others, but preference is given on the Puente hacienda, to the Sea Island, and Amazonia, (native,) for quality and productiveness. The Egyptian plant is small, but produces three crops per year of good quality. I have seen the native cotton growing at Chimbote without irrigation for four years, of valuable staple, but limited in quantity, as also along the valley of the river Seco, below the Cordillera. The cotton plants require eight or ten irrigations per year, but do not require annual renewal, as in the Southern States. They also give three crops every two years, with an average yield of one pound per plant, having about 1200 plants per acre. Native and Chinese laborers show great aptness in the cotton fields, and the best American gins and presses are now in use, from the impulse given to this article by its great advance in demand and price. A great deal of cotton is annually consumed in Peru, and it is destined to become a prominent place of export, having many physical advantages. While the plants in the Southern States are annually renewed and subject to injury from frost, rust, rot, the cut worm, the caterpillar, and the army worm, the Chimbote and Santa pampas require no cleaning, the temperature is never below 60°, no rain-storms occur, and no destructive insects are known. The difference in shipment to England between Callao and New Orleans will not exceed one-half cent per pound, and there is more than this difference in economy of production, and the market value of Peru cotton at Liverpool is second only to the Sea Island, as appears by recent quotations.

The production of rice and other grain has been amply tested and fully established. About 320 acres of the Puente were planted with rice last spring, giving an abundant harvest of superior quality. This hacienda contains a large rice mill, and sends large shipments to Callao. Wheat and other grain is raised here and in the valleys of the Cordillera in abundance. At Nepenia sugar cane is cultivated with much profit. Below Lima large quantities of grapes are raised, and a superior quality of wine and brandy manufactured. Though not much known in New York, the purity, strength, and flavor of the "Pisco,"

“Italia,” and “Muscatelle” liquors are justly celebrated on the Pacific shores. All the tropical varieties of fruits, oranges, lemons, plantains, chirimollas, paltas, figs, melons, &c., are common to this locality.

Very favorable results have been obtained at Santa from experiments with silk worms for two years past. The silk is of very valuable quality, and the mulberry trees grow well without being exposed to the attacks of insects common to other localities. In fact, with regard to the insect life of Peru, the absence of forests and swamps, and the character of all the uncultivated areas, prevent the development of insects as with us, and lands which are artificially irrigated are blessed with an exemption from blight and destruction, in their productions, of great consequence.

Cattle of valuable breed are raised here in large numbers for the Callao market, feeding on the strong grass, (*alfalfa*), which the grazing fields produce in profusion. All Spanish descendents are particular in breed stock, and the bulls of the pampas and bull-rings are splendid specimens of beauty and strength.

In a country where wagon roads and carriages are very rare, and with a people who are constantly in the saddle, much care is taken with the breed of horses, and the district of Santa is celebrated for its stock. There are about three hundred horses on the Puente hacienda. The saddle horses are all carefully trained and ridden with peaked saddles, heavy curb bits, and large wooden stirrups. The *montura* of a favorite saddle horse frequently costs five hundred dollars, from the elaborate ornaments in silver on its several parts. The gait is an amble or pacing step, trotting horses being rare, and the motion, for the ordinary speed of five or six miles per hour, is peculiarly easy. The horses are fed and watered but once a day, and on the coast are never stabled, and they have great endurance. Valuable breeds of mules are also kept for saddle use, and are preferred for mountain travel, though the Peruvian horses show great aptness for the severe and dangerous passes of the mountain roads, as I have had occasion to observe.

Limestone is found in many parts of Peru of strong hydraulic qualities. I was surprised to find, on the banks of the Santa River, a narrow vein of this mineral enclosed in trap-rock, but still more interested in large veins of valuable gas coal in the same formation. In the vicinity of Ferrol Bay a coal vein exists giving sixty per cent. of gas by analysis, and valued in Lima at twenty-five dollars (currency) per ton. Salt, saltpetre, and guano also are found in large deposits.

Thus, in agricultural and mineral wealth this district possesses latent energies of very great importance, which will promptly repay even partial development, while the commercial advantages of both bays are of equal consequence for imports, exports, and passenger travel. There is abundant room in either Ferrol or Samanco Bay for a large squadron to anchor, and the location is favorable for dry-dock constructions and uses.

The *method of improvement* for pampas of this kind by the formation of haciendas, or estates, and the comparative benefits, may be thus estimated from the basis of local experience.

Assuming a hacienda of 3000 acres, of which 600 are appropriated to buildings, mills, and various incidental uses, and the remaining 2400 applied to cotton cultivation, the investment of capital, exclusive of land or water supply, will be for—

300 Chinese,		\$ 90,000
Proprietor's house,		15,000
Chinese house,		5,000
Mills and machinery,		20,000
Carts, horses, oxen, &c.,		15,000
Adobe fences, gates, &c.,		15,000
Superintendence, &c.,		10,000
Investment,		<u>\$ 170,000</u>

The annual expenses will be for—

300 Chinese, annual pay,		\$ 14,400
Clothing,		6,000
Food,		21,900
Mortality, 5 per cent.,		4,500
6 Overseers,		3,600
Losses on stock, 10 per cent,		1,500
Expenses of proprietor,		4,000
Engineers and mills,		9,000
Contingencies,		5,000
		<u>\$ 69,000</u>

If we assume that, by neglect or otherwise, each acre of cotton contains but 800 producing plants, instead of 1200, and that the net yield of baled cotton is three-quarters of a pound, instead of one pound, the annual product will be 600 pounds per acre or 1,440,000 pounds in all, at an average cost, as above, of 4.85 cents per pound. Assuming freight, insurance, and commissions to make 6 cents total, the whole cost of production and sale at Callao is \$86,400. At the low rate of 16 cents per pound the net receipt is \$144,000 for the hacienda, after a liberal allowance for working force and expenses, or within \$26,000 of the capital invested, except for land and water. The actual cash value of an acre of cotton land in this valley is about \$60 per year, with sales at 16 cents per pound.

Assuming, however, that but 30,000 acres, or three-fifths of this valley, are cultivated, and that the annual increase per acre is but \$50, the annual value of the patent will be \$1,500,000 to those who operate it directly or by leases. This estimate does not include the productions from coal, guano, commerce, and fisheries of the bays and other sources of income.

If, on the other hand, we disregard the idea of cultivation, and irrigate the lands for sale, and assume so low a rate as \$50 per acre for net receipts, the intrinsic value of the patent is \$2,550,000 in return for an investment of less than one-tenth the sum.

From the limited number of reliable rivers on the coast line, irrigated property is in great demand in Peru, and fabulous sums are said to have been spent, at times, to supply water under difficult circumstances. The income, however, justifies a liberal expenditure, and the market is always sure for what is produced. The books of the Puente

hacienda show a return of \$130,000 the present year, for an expenditure of \$26,000, on a cultivated area of about 2400 acres, and on an estate where cochineal and cotton are but recently introduced, and, as yet, but partially planted. Nor have the hacienda proprietors availed themselves of the various labor-saving devices of our own country, which may be readily transferred to Peru.

A few months' experience of this region, as to its admirable climate, cheap labor and productiveness, and its facilities for expansion, in the immediate vicinity, also of very valuable silver mines, which exceed those of California in convenience of access and economy of food and labor, impressed me with a strong conviction of its comfort as a residence, and its promise of direct recompense to any judicious investment; and the people, as an entire class, are specially courteous to citizens of the United States, whom they regard as members of a powerful republic, on which, in more than one sense, the stability of their own depends. The occasional revolutions of Peru have no commercial consequence to foreigners, and are chiefly their inconvenient methods of presidential elections, in which neither ballots nor bullets have any prominence, and very little public or private injury is effected.

As an illustration of the spirit of the Peruvian government towards our citizens, we have a sufficient evidence in the grant of a patent covering the valley of Chimbote to New York capitalists, who now propose to irrigate and develop it, and who hold it under the strictest forms of Spanish law, and who also hold the right to open and work several of the richest silver mines of the Cordillera, about eighty miles east of this valley.

Iron-cased Sea-going Turret Vessel.

From the London Artizan, January, 1866.

The possibility of constructing armor-clad ships of moderate size, to carry heavy guns without sacrificing speed and sea-going qualities, has been repeatedly discussed in Parliament and elsewhere, and is a question that is occupying the attention of all who are interested in the development of our naval resources and the construction of the iron-clad fleets of the future.

Messrs. Laird Brothers, of Birkenhead, have just completed a vessel which, from her performance on trial and general appearance, bids fair to fulfil these conditions. She is an iron vessel of 1100 tons and 300 horse power, with a speed of more than twelve knots an hour on a draft of water of 16 feet, throwing a weight of broadside of 600 lbs. from her turret, besides carrying two 40-pounder rifled guns on the quarter-deck. The dimensions of the hull are about 200 feet extreme length, 35 feet breadth, 20 feet deep, and 1100 tons measurement. The hull is of iron of great strength, and is divided internally by bulk-heads into watertight compartments, so as to enclose her turrets, engines, boilers—all her vital points, in fact—in separate compartments. In addition to this provision for the ship's security, there is a double bottom under the engines, boilers, turrets, and magazines, extending up to the lower

deck. The armor plate is $4\frac{1}{2}$ inches thick, extending from her upper deck to $3\frac{1}{2}$ feet below the load water-line slightly tapering towards the bow and stern, to lessen the tendency to pitch in a seaway, and rests on teak backing 10 inches thick. The accommodation for the officers and crew is of a very superior description, well ventilated by means of skylights and side scuttles, and there is free communication from one end of the ship to the other by iron sliding doors on all the watertight bulk-heads. The spaces in the store room and magazines are ample for the stowage of six months' provision and ammunition. The turret is cylindrical in shape, covered with armor plates $5\frac{1}{2}$ inches thick, and is placed before the engine room, and is fitted with slides and carriages for two $12\frac{1}{2}$ ton 300-pounder guns on the system of Captain Cowper P. Coles, R. N. The rig of the ship is that of a brig, the foremast being fitted as a tripod on Captain Coles' patent, to give greater range of training to the guns in the turret. The engines of the ship are 300 horse power nominal, having cylinders 54 inches diameter, 3 feet stroke, driving a four bladed screw propellor, 14 feet 9 inches diameter, 17 feet 9 inches pitch. The cylinders have steam jackets and improved expansion valves. The trials of speed were made at the measured mile, and gave, as the result of four runs, a speed of 12.27 knots an hour. At the time of these trials the vessel was completed in every way except guns and sea stores, and had 100 tons of coal in the bunkers. The mean draft of water was 14 feet 3 inches; the engines made 78 revolutions, pressure of steam 25 pounds, vacuum 26 inches, indicated horse power 1650. The engines worked very well, and the boilers gave an abundant supply of steam. The ship was quick in answering her helm, and her steering arrangements are excellent, having one wheel in front of the poop and the second under the pilot tower forward.

This we believe is the greatest speed ever attained by an iron-clad vessel of this size, and bears out the statement made by Mr. Laird in the House of Commons, in the discussion on naval estimates in March last, that it would be possible to build vessels of this class to have a speed of 12 knots an hour, and the recommendation of Mr. Stansfeld, M. P., that the government should seriously consider the importance of constructing small fast vessels, carrying one or two heavy guns, at a high rate of speed, as, in his opinion, tending to increase our means of defence, and keep down the costliness of the naval service of the country.

For the Journal of the Franklin Institute.

Increasing the Speed of Steamers—Form of Propelling Blades—The Oar and Paddle.

To find out and properly employ the mechanical laws or principles impressed upon matter are among the leading purposes of our physical existence. Progress depends upon our knowledge of them, and in order to this, creation abounds with, or rather consists of, endless illustrations of them. Experimental philosophy has been deemed an employment worthy of angels, for, though treated as a secular busi-

ness it has the elements of a religious performance, for physical truths are as sacred in their origin and beneficent in their purposes as those of ethics, and seeking to discover them by experiment is an appeal to the Creator as direct as that of mental prayer for moral light. The form of invocation is the most consonant and when properly made is never in vain.

While few persons have the means, the taste and aptitude to carry out a series of costly experiments, there are cases where national resources may with propriety be drawn upon for the purpose. A nobler use of public money perhaps never can be made than to eliminate laws of the generation and application of inorganic forces. The current experiments of the Navy Department on steam are of this character, and, as elsewhere remarked, if wisely planned and executed, they will be of immediate and lasting advantage to the world. They ought not, however, to stop short of determining the plan of propulsion, which with a given power produces the greatest speed. Economy in the evolution of force is of little avail if what is saved be wasted in the application. It need hardly be stated that such experiments should not be given in charge to interested or contending parties. Nature—a metonymy for the Author of nature—listens only to sincere and patient inquirers. She has no answers for excited litigants.

Some things are overlooked by naval engineers. I think so, because I hold it an axiom that wherever persevering efforts to improve an art fail, some point or other has escaped notice or its importance was not suspected. Innumerable attempts, and at a fabulous expense, have been made for over half a century to increase the speed of steam vessels, with little or no marked success, and, what is to be regretted, the lesson which the failures inculcate is ignored—that art is the simulation of nature, and nature the climax of art. A profound conviction of the perfection of nature's mechanisms is the surest presage of success with ours, for when carefully studied there is no difficulty in detecting wherein we are wrong. Our engineers have not done this. They have not consulted natural propellers. Perhaps they did not think of them; or, it may be, they deem the principles of their action different from those they depend on. If so, they overlook the fact that those given us to work with are the same as the Creator employs—that there are no others.

In every branch of the arts talent is respected and expectation of their advancement pervades the general mind. A new propelling apparatus by a distinguished savant would draw crowds to behold it, and were it possible for a mechanical genius from a neighboring planet to give us a course of lectures on propulsion, with transmundane illustrations, who would stay away? Yet, strange as it is, we have continually before us working models in great variety from the hands of the Great Engineer himself, and give them no attention, as if He who formed the eye cannot see. We act as if the Author of forces does not best know how to apply them, and fondly imagine we can attain better results by deviating from principles He has established. The only excuse for this is, we are yet as children entering a school with little or

no ideas of what is to be learned in it. Engineers are but in training for the work before them. They do not yet know that the truest embodiments of mechanical laws are, and forever will be, those of nature, and that there can be no applications of science which she has not anticipated. As a class, the lesson is in advance of them. Occasionally one has recourse to the living volume when dead pages and diagrams in books fail to meet the exigence; but such are solitary cases—presages, however, of a legion in due time. It will then be with the mechanical student as with the lover of natural history, when, sick of artificial systems and dicta of schools, he exclaimed: “I do not want to hear the harangue of the exhibitor; I want to behold the exhibition itself.”

Let any one thus act and he will find—1. That in nature speed does not depend so much on dimensions as on the form of the propelling organ; hence, to change slow into swift movers it is not enlarged—it is often diminished—but the outline is changed that it may take a deeper hold of the fluid medium. This rule is absolute and so fully and variedly elucidated that there is no mistaking it in aerial or aquatic propellers. Our practice is in direct opposition to it.

2. In no case is the organ of one width. There is nothing like the horizontal parallelograms of the buckets or floats of our steamers. To gain speed the width diminishes from the widest part to a pointed extremity; that is, the shorter and broader the blade the slower the speed; and the converse, the longer, and tapered, and pointed, the greater the speed. This is so universally true that as naturalists detect in a single scale of a fish the species or genus to which it belonged, with equal certainty does the detached wing of a bird or tail of a fish indicate its relative velocity through air or water.

3. In no instance does a large sheet of wing denote rapid flight, but often the reverse. A certain amount of surface in one form produces double the effect in another. Of birds of the same average weight of body and wing surface, some are indifferent and others rapid flyers. The difference is caused by the removal of a portion from the width of the former's wings and adding it to the length of those of the latter, as may be seen in domestic fowls and wild ducks, and more obviously in sparrows and swallows. Some wings are scarcely half as long as the body, others equal it in length, while in the swiftest it often extends beyond the tail.

It is the same with occupants of the liquid ocean. Short, rounded, and triangular caudal fins are slow movers; lobated and pointed, without increase of surface, the quickest. The difference is due to the removal of a portion of the wide extremity of the former and adding it to the parts left, thus forming the nuclei of lobes. As the indentation is deepened and the lobes extended, speed increases, from the sole to the mackerel, the dolphin and the sword fish supposed to surpass in velocity all others. An additional and interesting proof of the principle is furnished in the class of unequal or heterocercal lobes; the longest giving additional speed in the direction, up or down, most essential for seizing prey or escaping from danger. And further, when

the material of both lobes is absorbed in one, as in the thresher or long tailed shark, the blade, as in some birds, being longer than the body.

As the loss of power from the inequality of pressure on steamers' buckets is not perceived, no attempts are made to avoid it. Every part meets with a resistance that increases with the distance from the shaft, because velocity or space passed through thus increases. It is as when a door is thrown open, the resistance of the air increases from the hinge to the handle, because the parts adjoining the latter are forced through three or four feet of the fluid, while those near the former move only as many inches. This result is unavoidable in rectangular blades, and in it we perceive the reason why nature forms none. In her swift propellers there is an equality of pressure on every section, and the centre of resistance, instead of being, as with ours, at the extremity, (which would break the wing-bones of every rapid flyer and paralyze the caudal fins of the shark and sword fish,) is in the middle of the blade. The simple and beautiful way in which this is done—simplicity is the acme of beauty—affords one of those instances that set the minds of philosophers aglow with admiration of nature's devices. *By tapering them, equal transverse sections, however varying in extent of surface, have equal power.* The tip of a wing being as efficient at the widest part—diminished surface being compensated by increased velocity or extended sweep.

But waste of power from inequality of pressure is not confined to buckets when in the water. It equally attends them when out of it. The resistance of the air as they are whirled through it, is greatest towards and at their outer edges, and therefore acts with the greatest effect. The number of horse power thus consumed in large steamers to no purpose but to retard their progress, I do not remember to have seen stated, nor, in fact, any reference to this source of loss. To what extent it would be reduced by the substitution of vertical, tapered, and pointed blades for ten or fifteen feet horizontal planks may be imagined. The loss of power from this cause in the oar is felt and sought to be avoided by feathering. How much more important, then, to guard against it when the blades are so many times larger and worked with greater velocity.

I have been asked by readers of the article on "Expansion and Propulsion," in the November number of the *Journal*, what form of blade is proposed, and have answered by referring them to the illustrated papers on the subject in Patent Office Report of 1849, the article on the "Influence of Form," in the *Journal* for 1855, and to another in the *London Practical Journal* of December, 1859. I was in hopes the subject would have been taken up before now, if not by the Institute, by some one of its mathematical correspondents. Till the law of configuration of blades be laid down and impressed upon practical men, fresh forms will continue to be offered like ventures in a lottery in hopes of obtaining the prize by chance. As a further attempt to draw attention to it, a few more pages are added.

Though differently applied, I suppose the true outline of the oar and the paddle the same, and that the like form and proportions are



equally fitted for steam vessels as for boats and canoes. It is singular that so little attention has been given to the oar by competing boat-clubs, and not by them alone. I do not know any modern dictionary of the arts or encyclopedia that has an article on it, except *Chambers*, now passing through the press. Without explanation, the annexed outline is said to combine greatest power and lightness. It appears to be a fair representation of the European and American oar. Still there are many blades that slightly widen to the end.

Pliny assigns the oar to two towns in Bœotia. The Copeans devised it, but the Plateans invented the broad and flat end. That was the Greek story. The implement doubtless dates from times anterior to the colonization of Greece.

It is worth observing that the aboriginal paddle of the Eastern was also that of the Western hemisphere. Indians on the lakes, the St. Lawrence, Mississippi, Orinoco, Amazon, and the Plata used the same type of blade as boatmen on the Nile, Euphrates, Tigris, and the Indus. If there were not more virtue in it than in others, how came it to be adopted where the arts were most cultivated? Certainly not for lack of investigation, but from a conviction of its superiority. For there is abundant evidence that propelling blades were more the subject of inquiry and experiment with advanced nations of old than in modern days, and, as some think, a nearer approach to the true form attained. Contrary to our practice, the resistance did not converge towards the end of their blades, and consequently required less expenditure of power to overcome it, an advantage impossible with ours.

In direct conflict with us, the Assyrians, the Egyptians, and the whole ancient world, rejected the parallelogram except for rudders, nor was it, nor is it, always adopted for them. To avoid its defects, or for other reasons, they preferred curved outlines, which veered between the ellipse and heart shape, or that of the common palm-leaf fan. Both occur in the sculptures, and are, with the oval, as much in use now as ever. The oar of the Egyptians, observes Wilkinson, (*Manners and Customs of the Ancient Egyptians*, vol. iii., first series,) was a long, rounded, wooden shaft, to which a flat board, of oval or circular form, was fastened; and it is remarkable, he adds, that the same is now used on the Ganges and in the Arabian Gulf. Dr. Pickering (*Races of Man*) says the oar of the Persian Gulf has a circular blade, which he met with at Mocha, Singapore, and Manila, and in the Tarawan Islands.

A few figures representing varieties of the oriental oar, the Roman and European one, and paddles, the parents of the oar, will add interest to the subject.

No. 1. From an Egyptian vessel of 16 oars represented on the walls of Medinet Haboo, at Thebes. The modern Kellek of the Nile, a raft supported on inflated skins, is kept, says Bonomi, in mid-stream by two rude oars, with blades the figure of a palm-branch fan. Similar ones are represented with Roman vessels. The ornamental rudders

on coins and figured in the hands of deities, appear to have been derived from the same source.

2. Wilkinson gives several vessels propelled by the oval and ellipse, and forms veering between them. There are six oars to each side of the vessel from which the figure is taken. The rudder is a large oar resembling ours. The rowers stand with their faces to the stern. This form of the oar is as common on the Amazon as on the Nile and the rivers of Assyria and India. (See Edward's Voyage up the Amazon: New York, 1847.)

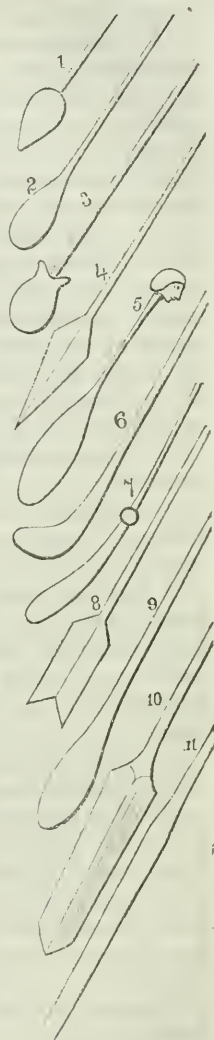
3. From a war galley of 20 oars. The enlargement of the upper end of the blades was probably adapted to some peculiar mode of fastening them to the shafts. The rudder similar to No. 2.

4. A large sail-boat; has 22 oars of this pattern on each side. The rowers have their faces to the bow, and push instead of pull. She is steered by three similar blades. This spear-shaped oar is a proof of mental activity in nautical devices. It shows that researches on the form did not terminate on the Nile, with elliptic types, where speed and economy of power were required, as they obviously were, in galleys of forty to fifty oars, like the one represented. Had these blades been of steel, and the weapon and oar united, such vessels would have been doubly armed. Nor is there anything improbable in the idea, since ninety camel-loads of pickaxes, pointed with *excellent steel*, have been found in a chamber of the palace of Khorsabad—an item of ancient war material.

Fosbroke refers to one of the Hamilton vases for an Etruscan acute-angled oar, tapering, like a pyramid, from top to bottom. He is mistaken, for the blade is not shown at all. Part of the shaft only is figured, about two inches wide where the hand grasps it, and wider where it enters the water. The oar of galleys are commonly thus represented, the blades being out of sight. See the French *Encyclopédie* for similar figures.

Whether the *paddle* is now used on the Nile, we know not, but that it was once a popular implement, appears from its oft recurrence in the sculptures. In the large volume of Denon it is figured some fifty times, varying in dimensions, but uniform in shape and proportions.

5. Is from the portico of the Temple of Tentyra. The handles of all terminate with a head. (In the figure it is made too large.) The blades are fac-similes of those of American Indians and Pacific Islanders, and, like them, were sometimes ornamented by carving, of



which an example is in Plate 132. This paddle occurs thirty or more times on the famous Zodiac.

The Assyrians appear to have modeled the oar after a different fashion than the Egyptians. Instead of the blade being a separate piece, it was narrowed and lengthened so as to be, as with us, a prolongation of the shaft. Another feature is its curvature; one worth considering. Mr. Pickering says the paddle of the Disappointment Islands is curved. In the Nineveh Sculptures are marine scenes; vessels loaded with and towing heavy timbers, propelled by four to five oars on each side. In some the rowers stand facing the bows, and consequently push the oar from them. No. 6 is from the thirty-first plate of Botta's splendid work. Some blades are narrower and not near so much curved. Of one vessel, (Plate 35,) the whole four vary more or less in dimensions and conditions, as if collected for an emergency, or the owners too poor to obtain a regular set. One resembles No. 9, and the blade of another is shattered and broken. In Plate 32 one of four blades is also represented as half worn out—incidents recorded by the sculptor that give additional value to the tablets.

7. There are Assyrian oars resembling this, but it is from a Norman vessel on the Bayeux Tapestry.—Fosbroke ii, 226.

8. Belonging to a Saxon ferry-boat on the same plate as the preceding. It might be supposed to have three blades, two in action and one behind them as a rudder. Possibly a defective representation.

9. From Valturius on Military Affairs, A. D., 1483, printed in Paris, 1532, page 315. This blade is represented as Roman. It has been continued more or less in use by Latin races. See Plates 12 and 31 on Fishing in *Encyclopédie*. It was the English oar in the fourteenth century.—See boat tilting in "Strutt's Sports and Pastimes."

11. Japanese oar from Perry's U. S. Japan Exhibition, i., 450. A similar blade appears in the French *Encyclopédie*.

10. Roman, from Stewichius' Commentary on Vegetius, MDCVI. The same blade is given in Hartman Schopper's Illustrations of Professions and Art in Europe, in the middle of the sixteenth century. The figures, singularly accurate in detail, are by the famous artist, Jost Ammon, 1568. The oar does not occur in the hundred plates of the Stradas, but is twice figured by Ramelli, in 1588, and precisely like No. 10. It is figured in the *Dictionnaire Universel Mathématique et Physique of Saverien*, Paris, 1753, (Plate 48,) with an elaborate article on the oar, to which the Encyclopedists refer.

Taking it for the common Roman blade, it deserves more than a passing notice, because old warlike nations gave, and with reason, special attention to the oar. Simple as it appears, naval conflicts were principally decided by it. Vegetius, on the manœuvres of a fleet, says: "The essential qualifications in the captain is vigilance; in the pilot, skill; in the rowers, strength. Naval engagements are fought when the sea is calm, and the ships, not moved by the wind, depend entirely on the force of the oars, either to attack the enemy's ships with their beaks, or, in their turn, to avoid the shock. In these movements,

it is strength of the rowers and the dexterity of the pilot that generally decides the victory.”—Clarke’s Translation.

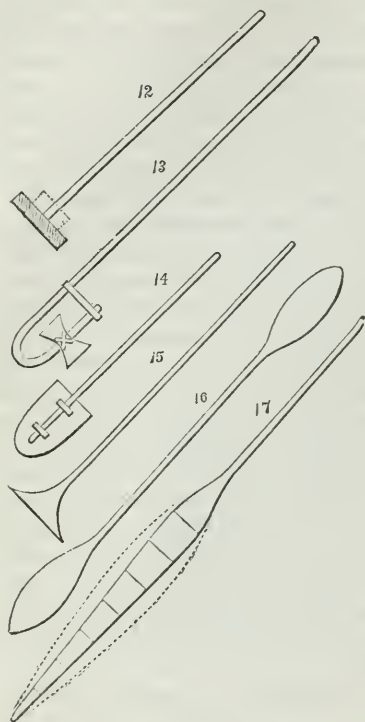
Not only for speed to avoid or overtake, but for momentum as rams to sink an enemy, vessels depended on their oars, hence the policy of increasing their number, first, by lengthening the hulls, and when that feature was exhausted, by widening them to admit of two rows, or benches, or banks, on each side, and thus doubling the propelling power. National rivalry next extended this feature, and to an extreme. A Corinthian built a galley of three banks or rows; the Carthagenians, not to be outdone, fitted some with four; Syracuse then sent them out with six, and at length the number rose to ten. Alexander is said to have had galleys with twelve rows on each side. Ptolemy Soter built one with fifteen; Demetrius, the son of Antigonus, and an expert mechanician, increased the number to thirty. Another of the Ptolemies built one of forty and his successor another of fifty. No doubt both were splendid failures, and in not a few of the others the tonnage must have exceeded the power. How ten rows of oars could be efficiently worked on each side of a vessel, raised above and extending beyond one another, is all but inexplicable, and but for the gigantic achievements of ancient engineers in other departments of the arts would be incredible. One thing is, however, certain—that the oar, worked by men, was employed in naval warfare to an extent that will never be equalled. At Salamis it drove Xerxes out of Greece, and it may be said to have given the empire to Octavius, for it was the superior agility of his galleys at Actium that gave him the advantage over the larger and heavier armed hulls of Antony and decided the victory.

Antony had recourse to a popular superstition to cover his defeat, and, what is singular, Pliny, himself a naval commander, gave credit to the ruse. He says a remora arrested the admiral ship during the battle and neutralized the utmost attempts of the oarsmen to move her! He confirms this by quoting a case within his own recollection, that of the galley of five banks of oars that conveyed Caligula the last time to Rome. She was suddenly stopped by the same little fish, “notwithstanding there were four hundred lustic men that labored with the oars.” Taking that number as the proper complement of a five bank vessel, the crews of some of the vessels of Demetrius and the Ptolemies must have amounted to thousands.

What the oar was, it still is in its modern substitute in steamers—a great disturber of nations. Of the paramount importance of speed, reference need only be made to the success of foreign blockade-runners in the late war and to the destruction of unarmed and unresisting ships and their loadings of merchandise by the British armed corsairs, *Alabama* and *Shenandoah*, that has shocked the moral sense of the world.

It would appear that not till modern times was the oar constructed as it now is in Europe and with us. The end was invariably rounded or pointed. It should, however, be stated that among the Assyrian tablets in the British Museum representing naval scenes, there is one in

which the blade was apparently designed to apply the principle of accumulated resistance at the end to the fullest extent. A parallelogram, of about eight inches by two, was attached to the paddle or shaft cross-wise, like a crutch or inverted T. (See No. 12.) It is obvious that such a blade would have more hold on the water than one four inches square, indicated by the dotted lines. Probably they were used chiefly as rudders, and the emergency called them into action as oars on the occasion represented. This would accord with the minute attention of the artists to details, examples of which have already been noticed.



As this blade resembles in its outline our steamers' buckets, it may here be remarked that some years ago the depth of those of one of our large vessels was reduced by removing four or five inches from their upper edges without affecting her speed. This fact I had from the late Mr. Stillman, the eminent founder of the Novelty Works, by whom the change was made.

13. Another oar, from a slab in the Kouyunjik gallery in the British Museum, which may as well be added, though the reason for the form and the material employed are left to conjecture. The artist represents wicker boats on the Tigris, similar to those still used on that river, each impelled by four men with oars of this singular construction. That it had some advantages may be presumed. Its introduction in historical tablets afford another proof that there was more thought and invention expended on the oar by ancient boat-builders than their modern representatives can boast of. See Bonomi's "Nineveh and its Palaces."

The remaining figures are from Wilkes' U. S. Exploring Expedition.

14. From the Kingsmill Islands, v., 49. The men are expert in managing their canoes, but their paddles are miserably made of coconut board or tortoise-shell, about six inches square, attached to a round stick.

15. Steering oar of the Paumotuans, Southern Pacific, i., 327, 345. An interesting example of intensifying the resistance at the extremity of the blades, in which respect it is related to No. 12, and to our steamers' buckets.

16. The Sooloo paddle, Indian Ocean, v., 333.

Dr. Pickering mentions it: "As we proceeded along the coast, many small canoes came around, having double out-riggers and double-bladed paddles." The same form is figured with the common Tahitian canoe, ii., 21, 36, and is that of Greenlander's double-bladed paddle.

The oar of the Spice Islands struck the Spaniards and Portuguese as a singular one. Speaking of Banda, Argensola (Discovery and Conquest of the Molucco and Phillipine Islands) says: "The slaves ply the oars, which are like wooden shovels; they make the vessel fly by main force, and serve to lade out the water when there is occasion. The figure is not given.

17. Fuegian paddle, i., 116, 123. Remarkable as being the longest and narrowest of blades, straight sided too.

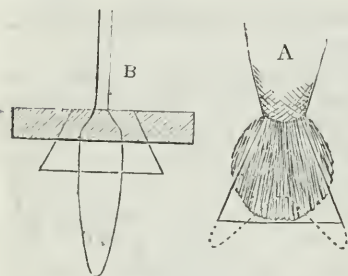
The Magellenic waterman, says Pickering, are far less advanced in the art of navigation than their northern brethren of the Straits of De Fuca; their canoes are smaller and inferior in construction. They are not known to venture forth into the open sea, and even the Falkland Islands, although so near the coast, appear to have remained unvisited by them. Slings and spears are their only weapons, the strings of the former being animal fibre, and the heads of the latter bone, in shape and attachment analogous to the bone-pointed arrows and salmon spears of the northwestern coast. A further unexpected analogy is perceived in the shape of the paddles, the Fuegians making the blade even narrower than do the northwestern tribes.

Viewed either with its straight sides or their expansion into the elliptic form, as per the dotted lines, unless I am greatly mistaken, this blade approaches nearest of the whole to the true one, to that which with a given power produces the greatest effect. Equal transverse sections, (as marked,) though unequal in area, are equally effective, and the centre of pressure is near the middle. Such is the principle invariably adopted by nature. Without it there had been no rapid flyers and swimmers, and without it all our efforts to gain speed must forever fail. If this blade is the best for canoes, it is the best for steamships, which are merely large canoes. The wing of the condor is but the humming bird's enlarged, and so it is with the propelling fins of the whale and the minnow.

Is it asked, How came the most wretched of American aborigines, a people wholly destitute of clothing though living near the Antarctic Circle, by this blade? How account for this and for the general uniformity of thought among barbarians of other lands on the implement? By that which is as essential to guide man ere the reasoning powers are awakened, as to the lower tribes, *instinct*, as it is called, and but for which our species had early perished. Without the resources of art, savage man lives close to nature, depends wholly upon her, and is governed by her unerring suggestions. By her he is led to mechanical devices as birds are to build nests, wasps to make paper, and bees to practice geometry. He is, as it were, intuitively and unwittingly led to adopt principles which in civilized states are only recognized and realised after long observation and much blundering in wrong directions. Other aboriginal things might be mentioned, and the Te-

piti or Cassava Press among them, that put to shame some of our costly and complicated contrivances. It is thus that people the most enlightened may take lessons from the most ignorant. The steam fleets of the world may be benefited by the paddle of barbarians.

The progressive stages of natural speed, each starting with the initiation of a new feature in the blade and increasing with its development, will be better understood by aid of the diagrams A, B, than by words alone. The shaded circular fin of A represents that of the sole



and some of the slowest swimmers. To meet the requirements of more active classes, it undergoes successive modifications. The sides gradually straighten, the end widens, and its convexity depressed till the outline becomes that of a truncated pyramid or triangle—the terminus of the second stage. Then for swifter, and up to the swiftest movers, another change begins which neither human art nor science could have anticipated. A portion is removed from the middle of the base line of the triangle and added

to its end as lobes. (See dotted lines.) The *power of the blade now increases with the depth of the fork and length of the lobes*, and even still further, by merging both into one, an instance of which has already been quoted. (See also Plate 3, of Patent Office Report of 1849.)

Such is the virtue of *form* and of form alone, for the three blades in the diagram are equal in area—the same amount of surface in different shapes—while the centre of resistance in the last form is in the middle of the blade.

This appears to be nature's ultimate type of propellers—aquatic, aerial and amphibious—and therefore the most perfect of patterns for us to study. It is impossible for human ingenuity to equal it. When once engineers adopt it, they will be conscious of possessing the means of attaining not only the higher, but the highest rates of speed, with harmony of motion and economy of power. A new epoch of navigation will begin with it. Steamers, instead of resembling organisms, whose blades make more noise than dispatch, will rival the flight of the frigate bird, whose power, extent of wing, and oceanic range constitute it the eagle of the sea. Limited as we are neither in power nor in propelling surface, there is nothing wanting to effect this but to give the true form to that surface.

Such is the Creator's plan. Now look at ours in the shaded blade of the diagram B, a long, horizontal parallelogram, antipodal in form and action to any in nature, and vastly inferior to the rudest ever proposed. It is so outré, that its adoption seems rather a result of accident than reflection. An Indian adrift in his canoe, or a sailor in like circumstances, might work his way with it, but not for a moment would either use it as we use it. Both would unhesitatingly plunge it end-

wise into the water. Instinct would lead them thus to take good hold of the fluid near them, instead of extending the board laterally for a weaker hold further off, and requiring greater labor to get it.

Cut the board into three pieces and unite them as in the diagram and the propelling power will be greatly increased, but not near so much as is now required. As at A, the triangular form should be considered the basis of a better. In nature it is chiefly confined to a few small fishes. In larger ones it is invariably forked. The third stage for us is therefore the same as in nature, the horizontal plank must become a vertical lobe. Is it asked, Why not two lobes as in swift swimming fishes? because the organ in them is designed to answer the purpose of dual blades in birds, and paddle-wheel steamers, like them, have propellers at each side.

An impression prevails among some men that it may be all very well to talk about nature in books, but that it will not do to follow her as proposed, because her propellers are so different from ours in their materials, their functions, and forces. They misunderstand the proposition, or do not give it due consideration. If they admit that natural mechanisms are perfect expositions of mechanical laws, they have misgivings about the action of the same laws in artificial constructions, as if levers of bones and cords of sinew act differently from those of metal and flax. As we can no more alter or affect one of the laws of force and motion than create matter, all that we have to do, or can do, is to construct our machinery in accordance with them, and that is what is meant by imitating nature, not, as some would affect, to make our locomotives run on feet. And where is there a law or principle more clearly illustrated and enforced in nature's repository of mechanical marvels than that which makes the speed of bodies moving through fluids to depend on the taper and length of their propelling organs.

In lightness and flexibility natural blades are unrivalled, but for our purposes those of inorganic materials are better than any of living tissues, and so is the continuous rotary movement we give them than the alternating action of natural ones.

As the world is more governed by custom than by reason, time is required to loosen its hold in mechanical as in other matters, and the more so when large interests are involved. This is right. It is not to be supposed that proprietors of ocean and river lines of steamers, or the government, can be led to introduce changes in propelling machinery which their professional advisers do not endorse. Still, whenever sufficient reasons are adduced which render an experimental test expedient, it surely is the part of prudence to have it made. The cost of changing the blades of a vessel for one or two trips is hardly worth considering in view of determining the form of blade in which efficiency and economy of power are pre-eminently combined.

To initiate the proposed change, a medium blade between Nos. 10 and 17 might be adopted. By it the width of the present wheels would be reduced four-fifths if not more, and if the diameter be nominally it would not be virtually enlarged, as the real radius would be

from the centre of the blade to the axle or shaft. In new vessels it might be reduced, as there would be no necessity, as now, to place the shaft so high above the water. Instead of the edges of ten or twelve foot planks brought slap down upon it, the pointed ends of the proposed blades would silently enter it. Whenever a machine is on a wrong basis, minor movements are brought in to uphold it that increase the wear and tear and consumption of force. On a true one, the principal and adjuncts are in union and the work done with a minimum of power. As in the present case, any objection brought against it tends, when examined, to confirm it; thus, it has been intimated that the velocity of the present wheels might be too great for blades of the proposed dip. Supposing, but not admitting, some truth in this, the speed of a steamer no more depends on the rapidity with which her blades strike the water than that of a bird on its wings striking the air. She may double her revolutions and go slower. With fewer steps, the lad on stilts outstrips his associates on the ground, but turn to true exemplars, and the rule will be found to hold that lengthened blades with *diminished velocity* increases speed. Thus the laborious flutter of the partridge is exchanged for the easy and silent sweep of the eagle and hawk. Our steamers, with their clattering buckets and tremor, resemble the former instead of the latter. But marine propulsion is in its infancy, and the science of natural forms has not left the cradle.

E.

New York, December, 1865.

Experiments on the Strength of Cement, Chiefly in reference to the Portland Cement used in the Southern Main Drainage Works.

By JOHN GRANT, M. Inst. C. E.

From the London Civil Engineer and Architect's Journal, January, 1866.

This communication related to an extensive series of experiments, the results of which were recorded in voluminous tables forming an appendix to the paper, carried on during the last seven years, with a view to insure, as far as possible, that only cement and other materials of the best quality should be employed in the Southern Main Drainage Works of which the author had charge as resident engineer.

As a preliminary step, samples of Portland cement were obtained from all the principal manufacturers for the purpose of experiment. The average weight of these samples were found to be 108.6 lbs. per bushel, and they sustained breaking or tensile strains at the end of a month, varying from 75 lbs. to 719 lbs. upon $2\frac{1}{4}$ square inches. A clause was then inserted in the specifications to the effect that the Portland cement to be used in the works should be of the very best quality and ground extremely fine, weighing not less than 110 lbs. to the struck bushel, and capable of resisting a breaking weight of 400 lbs. upon an area $1\frac{1}{2}$ inch square, equal to $2\frac{1}{4}$ square inches, seven days after being made, and after being immersed in water for the whole of that time. The standard was subsequently raised to 500 lbs. on the same sectional area, which was that used throughout the experiments. During the last six years 70,000 tons of Portland cement had been used in these

works, which extended over a length of 18 miles and had cost £1,250,000. This quantity of cement had been submitted to about 15,000 tests, at a cost of only five farthings per ton. The machine devised for showing the tensile strain was a lever balance constructed by Mr. P. Adie, (Assoc. Inst. C. E.,) and its first cost was from £40 to £50. It was so simple that an ordinary workman could be trusted to test the cement, and the cost for labor did not exceed £80 per annum for each machine.

The manufacture of Portland cement required extreme care in the admixture of its two simple and well known ingredients, clay and chalk, it being necessary to vary the proportions according to the quality of the chalk; thus, in white chalk districts, the clay formed from 25 to 30 per cent., and in grey chalk districts from 16 to 20 per cent. of the whole bulk. The manufacture was carried on almost exclusively on the banks of the rivers Thames and Medway; the clay, which should be as free from sand as possible, being obtained from the creeks and bays between Sheerness and Chatham. Long experience now enabled the clerks of works and others to detect the qualities of the cements by color and by weight. Very strong Portland cement was heavy, of a blue grey color, and set slowly; in fact, the longer it was in setting the greater was its strength. Quick-setting cement had generally too large a proportion of clay in its composition, was brown in color, and turned out weak, if not useless. In the first schedule of prices 2s. 3d. per bushel was inserted; but this was far above its present market value.

But the tests were not alone sufficient. It was essential that constant supervision should be exercised to insure that only clean and sharp sand should be mixed with the cement; that the cement was only supplied with sufficient water to reduce it to a state of paste, which was best accomplished by means of a perforated nozzle at the end of a pipe or watering can; that the bricks or stones were thoroughly saturated with water, so that in setting the cement might not be robbed by absorption of the moisture necessary for its perfect hardening; and that a current of water was prevented from passing over the cement, or through the joints during the progress of setting, as this would wash away the soluble silicates.

The results, as a rule, were the average of 10 tests, the samples being immersed under water from the time of setting to the time of testing. The tables showed that, during the last six years, 1,369,210 bushels of Portland cement had been submitted to 11,587 tests, and that the cement was found to be of the average weight of 114.5 lbs. per bushel, and to possess an average tensile strength of 608.6 lbs. upon $2\frac{1}{2}$ square inches, being $51\frac{1}{2}$ and 21 per cent in excess of the two specified standards. It was also ascertained that, provided Portland cement kept free from moisture, it did not, like Roman cement, lose its strength by being kept in casks or sacks, but rather improved by age—a great advantage in the case of cement which had to be exported. Experiments, conducted over periods varying from one week to twelve months, with Portland cement weighing 112 lbs. to the imperial bushel,

gauged neat, and mixed with varying proportions of different kinds of sand, showed that neat cement was stronger than any admixture of it with sand; that mixed with an equal quantity of sand, (as had been the case throughout the Southern Main Drainage Works,) the cement might be said to be, at the end of a year, approximately three-fourths of the strength of neat cement; that with two, three, four, and five parts of sand to one of cement, the strength was respectively one-half, one-third, one-fourth, and about one-sixth that of neat cement. Other experiments show that at the end of twelve months, neat cement kept under water in a quiescent state was about one-third stronger than that which was out of water, both indoors and exposed out of doors to the action of the weather; that blocks of brickwork or concrete, made with Portland cement, if kept under water until required for use, would be much stronger than if allowed to remain dry; and that sea-water was as good for mixing with Portland cement as fresh water. Bricks of neat Portland cement, after being made three, six, and nine months, withstood a crushing force of sixty-five, ninety-two, and one hundred and two tons respectively, or equal to the best quality of Staffordshire blue bricks; and bricks of cement mixed with four and five parts of sand, bore a pressure equal to the best picked stock bricks; while Portland stone of similar size bore on its bed a crushing weight of 47 tons, and against its bed somewhat less, and Bramley Fall stone sustained on its bed $93\frac{1}{2}$ tons, and against its bed $54\frac{3}{4}$ tons. Portland cement concrete, made in the proportions of one of cement to six or eight of ballast, had been extensively used for the foundations of the river wall and the piers of the reservoirs at Crossness, as well as for the foundations generally both there and at Deptford, with the most perfect success. It was thought that it might be still more advantageously used as a substitute for brickwork or masonry, wherever skilled labor, stone, or bricks were scarce, and foundations had to be made with the least expenditure of time and money. Whenever concrete was used under water, care must be taken that the water was still, as a current, whether natural or caused by pumping, would carry away the cement and leave only clean ballast. Roman cement, though about two-thirds of the cost of Portland, was only about one-third its strength, and was, therefore, double the cost when measured by strength. It was besides very ill-adapted for being mixed with sand.

In conclusion, the author, whilst recommending Portland cement as the best article of the kind that could be used by the engineer or architect, warned every one who was not prepared to take the trouble, or incur the trifling expense of testing, not to use it, as, if manufactured with improper proportions of its constituents, chalk and clay, or improperly burnt, it might do more mischief than the poorest lime. Further experiments were desirable, on the strength of adhesion between bricks and cement, under varying circumstances; on the limit to the increase of strength with age; on the relative strength of concrete made with various proportions of cement and ballast; and on the use of cement in very hot climates, where probably extra care would be required in preserving the cement from damp, and keeping

it cool until the process of setting had been completed. On these and other important points, the author trusted that all who had the opportunity would record their observations and present them to the Institution.

Proc. Inst. Civ. Eng., Dec. 12, 1865.

On the Adhesion of Locomotive Engines and Certain Expedients for Increasing or Supplementing that Function. By VAUGHAN PEN-DRED, C. E.

From the London Mechanics' Magazine, November, 1865.

(Concluded from page 91.)

Returning to the inside cylinders, we find that the piston rods are provided with cross-heads running in guides, although these last are hardly required, each piston driving two connecting rods. The piston rod of the leading cylinder is exactly over the mid-rail, and, of course, opposite to that of the after cylinders. Thus, neither of the cylinders is in line with the shafts they have to drive. But the two connecting rods from the forward cylinders proceed right and left to the two horizontal cranks on the forward vertical shafts and put them in motion precisely on the well-known system used by Cartwright, in Watt's time. The connecting rods from the after cylinder, however, do not take the crank pins of the actual trailing wheels, but instead they are forked and jointed on to the side coupling rods. The result is rather a singular motion, not very easy, perhaps, to trace out through all its stages and speeds, but giving in effect a result equivalent to that which would be produced if the cylinders worked on cranks at right angles to each other, and thus dead points are eliminated. Each of the vertical shafts is supported in two boxes, and these boxes are made to approach each other in order to regulate the amount of grip on the rails in the following manner: Across the engine, between the leading and trailing vertical shafts, runs an endless screw carrying outside the frame a worm wheel, into which a vertical screw gears. By causing the screw to revolve by means of a hand wheel, the transverse screw can also be put in motion. The brasses of the vertical axles are carried in cast iron boxes provided with grooves, which slide on suitable ribs placed across the engine. Exactly over the mid-rail are located two horizontal worm wheels, gearing with the transverse screw before mentioned. These wheels turn on axles fixed in the frame. To each is keyed a pair of eccentrics or cams projecting in opposite directions. These rotate within a pair of boxes, one for each eccentric, and these boxes are connected by rods with the lower boxes of the vertical wheels, strong helical springs being interposed in such way as to produce an elastic strain on the grip wheels. In order to make the wheels compress the rail, the transverse screw is caused to revolve, thus putting the large worm wheels in motion, and with them the eccentrics, which, in time, cause the low boxes to approach each other across the engine in pairs, and this motion is communicated

to the four upper boxes through the medium of four vertical rock shafts and links. All this is very complex, it must be admitted, and has been greatly improved upon since; but we shall do well to bear in mind that this engine accomplished all it was designed for, which was to take 16 tons up inclines of 1 in 12 or 13 at speeds of $7\frac{1}{2}$ miles per hour or thereabouts on straight roads. The engine being completed was almost immediately afterwards tested at Whalley Bridge, on the Cromford and High Peak Railway, on a short piece of line expressly laid down for its gauge—3 feet 8 inches. The first trial took place on the 5th of January, 1864. There were two inclines on the line—one 200 yards long, with a gradient of 1 in 13; the other 550 yards long, on a grade of 1 in 12, with curves of about two chains or 132 feet radius. The engine easily surmounted these, with four wagons containing 26 tons of ballast—a performance which was at that time unique, considering the weight of the machine. In order to realize its exact character it may be remarked that these inclines are half as steep again as Holborn Hill at its steepest part.

Shortly after this engine had been finished, Mr. Alexander was instructed to prepare designs for a second, which differs in many important particulars from the first one. All the arrangements are much simplified; the boiler power is increased, and the results obtained have been much more satisfactory. All the experience gained in the construction of the first has been made use of, and, although the machine is not yet quite what it should be, it is at least comparatively perfect, and has proved itself safe and efficient. Built partly of steel, its net weight is 33 tons, and loaded 16 tons 17 cwt., inclusive of the extra machinery of the horizontal wheels, weighing 2 tons 13 cwt. The boiler is 8 feet 4 inches long, and 3 feet 2 inches diameter, and contains 158 tubes $1\frac{1}{2}$ inch external diameter. The total heating surface amounts to 600 superficial feet, that of the grate being 10 feet. There are only two outside cylinders, 15 inches diameter, and 16 inches stroke, which work both the bearing and gripping wheels as follows: Across the forward end of the framing, in advance of the smoke-box, is placed a species of box girder, carrying at the middle of its length two bearings. Bolted to the side frames are two cast iron boxes bored out to receive each a rock shaft, the inner ends of which are carried by the bearings in the box girder. The outer arms of these rock shafts are coupled to plungers or rods working in guides, which are coupled to the outside wheels by ordinary forked connecting rods. Each piston has, so to speak, two rods, one proceeding through the forward end of the cylinder, the other through the back. The forward rod carries a cross-head working in guides, the cross-head being fitted with a pin taking into a box working in a slot in the second arm of the rock shaft. This is rather a roundabout way of driving the bearing wheels, but it works very fairly, and is susceptible of improvement in the matter of proportion more than anything else. Thus the crank pins are needlessly long, and the outer rocker arm too heavy. The inner wheels are united as before by coupling rods, the arrangements being much the same as those in the first engine. The inner

piston rods drive the furthest crank by means of ordinary connecting rods, working horizontally, of course. It will be seen, however, that so far no connexion whatever exists between the pair of horizontal wheels at the right hand side of the rail and those of the left. It was at first thought that no difficulty would be experienced in getting over the dead points, the engine once in motion. This was not the case, and gearing is used to couple the two systems. Instead, too, of the excessively complex compressing gear used in the first engine, a single right and left handed transverse screw, taking into deep bosses formed on longitudinal bars is employed. These bars rest on helical springs interposed between them and the two sliding frames carrying the bearings of the gripping wheels. The engine has been built by Mr. Cross, of St. Helens, who deserves much praise for the skill and care displayed in the construction, and I may add the design of this engine.

The next system claiming our attention is the "auxiliary steam tender" of Mr. Sturrock, engineer of the Great Northern Railway. It consists simply in the application of a pair of cylinders to the ordinary tender, which are supplied with steam from the boiler of the engine through a copper pipe, bent to easy curves, and, therefore, sufficiently elastic to permit of a flexible connexion between tender and engine. The scheme is not strictly novel, steam tenders having been used to work the coal traffic between Rive de Gier and St. Etienne from 1845 up to 1853. These engines were built by Verpillieur for a 40 lb. rail, and being found too light for their work, cylinders were added to the tenders, and, with this addition, they conducted the traffic on an incline of 1 in 60 with considerable success. Verpillieur's arrangement was clumsy as compared with Mr. Sturrock's, the steam pipe to the tender being led overhead across the footplate, while stuffing boxes were employed to compensate for its rigidity. Forty-six steam tenders are now at work on the Great Northern, but they are not yet fully employed, as certain engines to which they are intended to be fitted have not yet been delivered to the company. The waste steam from the tender cylinder is led through a few tubes placed within the tank, in order to raise the temperature in the feed-water, by which a considerable saving in fuel is effected. The coal traffic of the Great Northern is worked at the high average speed of twenty miles per hour, including stops; and as the line abounds in inclines of 1 in 200, several of them three and four, and one as much as eight miles long, while the weight of the train averages 280 tons, it is evident that a good deal of power is necessary. The steam tender engines have 16 inch cylinders, 24 inch stroke, and six coupled wheels 5 feet in diameter. It was found in practice that these engines made more steam than they had adhesion to work up in winter though not in summer. The auxiliary tenders have cylinders 12 inches diameter, 15 inches stroke, and six wheels, all coupled, 4 feet 6 inches diameter. They weigh full 29 tons. After they had been in use a short time it was found that the boilers in their normal form did not make sufficient steam for the additional adhesion. The fire boxes were therefore removed, and re-

placed by others of larger size, the inclined grate being carried above the trailing axle. The grate surface is thereby increased from $17\frac{1}{2}$ feet to $26\frac{1}{2}$ feet, the weight of the engine being increased by 10 cwt. Engines thus altered take, I understand, gross loads of 450 tons, their normal load being increased from 30 wagons, containing 7 tons of 21 cwt. to the ton in each, to 45 wagons, or 315 tons net, up inclines of 1 in 178. The tenders are in use but a couple of years, during which time they have run 1,011,963 miles up to the 26th of last August, 430,000 of these having been run during the six months ending 30th of June. The system has, I believe, proved thoroughly successful, the power of the engines being increased by about 50 per cent. in return for an expenditure of £450 to £500. The tenders weigh empty about 18 tons, or half as much as the engine, so that the consumption of coal and water while running does not practically affect the adhesion. The entire idea thus embodied will be seen to correspond in many respects with those of Flachet and other continental engineers. The details have been worked out with so much care that we must accord Mr. Sturrock a fair proportion of the credit due to an original inventor.

I have said that I would refer to the different modern systems of supplementing or increasing adhesion in the order of their importance. I must add that I measure this importance, not by the skill or talent of the inventor or by the originality of his views, but by the degree in which these have been reduced to practice, and the specific object they are intended to subserve. It is possible that the system to which I now beg leave to call your attention is more strictly novel, if not remarkable, than either of those we have just considered. Mr. W. B. Adams, well known for his inventions in connexion with railways, has produced an engine for sharp curves, which also embodies a means of supplementing adhesion well worth attention. The idea of coupling chairs by the aid of friction wheels has been broached before, but never in the form which Mr. Adams has given it. According to this arrangement the whole weight of the engine is supported on all the wheels as driving power, and that while permitting the engine to roll round curves of as small a radius as a chain and a half, with a total wheel base of 20 feet to 24 feet. This is effected by applying friction wheels between the two pairs of central and end wheels, their axles passing between the boiler and frame. The two pairs of middle wheels are applied in the ordinary way with axle guards, one pair having a crank axle attached to a pair of inside cylinders, and connected by side rods to the other pair of wheels, both pairs having inside bearings. The end wheels have outside bearings giving a wide spring base which steadies the engine. The axle boxes are of the ordinary kind, and they have no horn plates which would be in the way. The bearing springs swivel on a centre pivot, and support their load from long rods attached to balls and sockets, connected with scroll irons or brackets on the frame. Thus free movement is given to the leading and bearing wheels and axles, both forward, backward, laterally, and diagonally. But it is essential to control this movement, so that the axles may only move in a true radius with the curves of the rails.

To accomplish this the whole axle between each pair of wheels is fitted with a curved bed struck from a centre equal to one-fourth the total wheel base. This curved bed works on a second frame, corresponding to it in form, fixed to the inside frame of the engine. Thus these end axles with their wheels work in the curve, impelled by their flanges against the rails; and this curved frame takes all the thrust caused by the pressure of the friction wheels between the lower wheels. This pressure can be increased or diminished at the pleasure of the driver by levers acting on volute springs, or the wheels may be lifted altogether from contact. The three pairs of wheels at each end thus act simultaneously, the driving power at the crank axle impelling the whole. On a straight line the gravitating action of the spring shackles keeps them vertical; on the curve the pressure of the flanges places the end wheels at an angle, so that in the inside of the curve the end wheels approach the centre and on the outside go further apart, their axle reclining from the horizontal position to one side or the other. The friction wheels work independently on their axle, and the tires are provided with flanges to interlock them with the centre and leading or trailing wheels. If the connected wheels were rigid on their peripheries there might be a tendency to jump and slip, as with all rigid wheels, and so lose their hold. To insure against this defect the wheels are all provided with springs underneath their tires, which allow them to fit each other and ensure adhesion. The engine is fitted with a pair of steam cylinders on each side of the frame, the piston being pressed down by spiral springs inside to keep the brake out of use, and when the steam is admitted the springs are overpowered and the brakes are lifted into contact with the wheels. In order to increase the adhesion for very steep gradients the flanges of the wheels are made *V* form, and enter a corresponding rail, traveling on the ordinary rails when not on steep inclines.

This paper has already extended to such a length that I can do little more than glance at the last section of my subject—the application of magnetism as a means of increasing adhesion. It happens, however, that the idea, although often tested on a large scale, has resulted in nothing; nor is it likely that it will ever be resorted to in practice. It may, in short, be regarded more in the light of an ingenious abstract mechanical device than in that of a practical expedient likely to serve a really useful purpose. I believe the idea is very old, M. Weber being the first to suggest it, while Liebig mentions it in many of his earlier letters; but the first patent taken out, in this country at least, bears date 1850 only. It was secured by M. Amberger, to whom the credit of the invention, such as it is, is due. Its history is very simple. In or about the year 1850, the Austrian Government appointed a commission to inquire into the best means of providing sufficient adhesion to work the Semmering incline, with grades averaging 1 in 47. The commissioners applied, among others, to M. Amberger, an engineer of some eminence, who suggested the plan of magnetizing the driving wheels by electricity. Amberger's suggestion was adopted by the commission, and funds were placed at his disposal

to make experiments. He called in the assistance of an electrician, M. Nicklés, and after some models had been constructed, and the fact demonstrated that it was possible to increase the co-efficient of adhesion, they proceeded to test the scheme on a large scale. For this purpose an engine on the Lyons Railway was placed at their disposal. The engine weighed 30 tons, supported on six wheels, of which four were coupled. It was found, however, that this engine had more adhesion, thanks to the coupling, than it had cylinder capacity to work up, and therefore the coupling rods had to be removed. The magnetizing apparatus consisted simply of a coil of insulated copper wire wound on a species of brass bobbin surrounding the lower part of the wheel. The battery consisted of 64 Bunsen elements, and the length of the wire was about 1700 yards. The force of attraction equaled, when the train was at rest, 639 kilogrammes, or 12 cwt. 2 qrs. 11 lbs. for each wheel; and so far it is obvious that there was a decided gain. But a very singular phenomenon, and one altogether unanticipated, supervened the moment the train was put in motion, which was simply that as soon as the wheel began to revolve the force of attraction diminished. Thus, at thirty revolutions per minute the force of attraction fell off from 12·5 cwt. to 5 cwt.; while at sixty revolutions it fell to but 3 cwt. 27 lbs. Without entering deeply into the theory of the electro-magnet, this may be easily accounted for in the following way: The top of the wheel is converted into one pole of the magnet—say the north—the bottom of the wheel into the south pole; but the south pole is more strongly magnetic than the north, because it is next to the coil. As the wheels revolve, however, the south pole continually becomes the north, and *vice versa*. But it is well known that electro-magnets retain small charges of magnetism after the current is broken, while any change of polarity requires a little time to be fully accomplished. When the wheel or wheels revolve rapidly this time is not allowed, and the result is a species of confusion in the polarities, and a consequent weakening of the magnet. Nicklés then produced another system, in which the coil is disposed in the same plane as the wheel, with which he obtained better results, the magnetism not being affected by the revolution; but the arrangement is inapplicable to engines of the ordinary construction, with high drivers, and must interfere so considerably with the entire design of the engine in any case, that I cannot think it likely that it will ever find its way into practice. Indeed, the best results Nicklés obtained only gave an increase of adhesion equal to 8·5 per cent.—a very poor return indeed for the trouble and expense incurred in the construction and manufacture of a complex electrical apparatus. The idea is still being worked out, I believe, both here and in America. Sir Charles Fox, for example, has recently tried many experiments on the Great Eastern Railway, which have ended in nothing, except in proving that a few handfull of sand enabled the engine to surmount inclines with a given load which it was unable to cope with even when the wheels were powerfully magnetized.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

The Lenoir Gas Engine. By FRED. J. SLADE.

Having had considerable opportunities for observing the practical working of this machine, the writer has thought some of the phenomena of its operation of sufficient interest to be made public. The principle of its action is as follows: The piston moving at the beginning of its stroke by the momentum previously imparted to the fly-wheel, draws into the cylinder, through a suitable slide valve, a mixture of common illuminating gas and air. When the piston has moved through a little less than half the stroke the valve closes, and an electric spark is introduced into the cylinder and ignites the gases. The expansion caused by the heat of combustion drives the piston during the remainder of the stroke.

The composition of coal gas is not the same in all cases, but varies with the kind of coal used in its manufacture, and the extent to which the distillation is carried. A constitution probably not far from the average in our cities would be expressed by

Olefiant gas,	.	.	.	.	.	.	7
Light carburetted hydrogen,	.	.	.	.	.	.	56
Hydrogen,	.	.	.	.	.	.	21
Carbonic oxide,	.	.	.	.	.	.	11
Nitrogen,	.	.	.	.	.	.	5
							100

Now, in combustion 1 cubic foot of olefiant gas unites with 3 cubic feet of oxygen and gives 2 cubic feet of carbonic acid and 2 of vapor of water. One cubic foot of light carburetted hydrogen unites with 2 cubic feet of oxygen and gives 1 cubic foot of carbonic acid and 2 of vapor of water. One cubic foot of hydrogen unites with one-half a cubic foot of oxygen and gives 1 cubic foot of vapor of water. One cubic foot of carbonic oxide unites with one-half a cubic foot of oxygen and gives one cubic foot of carbonic acid.

The result of the combustion of 100 cubic feet of coal gas, therefore, will be represented as follows:

		Oxygen.		Carbonic Acid.	Vapor of Water.
Olefiant gas,	7 +	21	yields	14	14
Light carburetted hydrogen,	56 +	112	"	56	112
Hydrogen,	21 +	10½	"		21
Carbonic oxide,	11 +	5½	"	11	
Nitrogen,	5		"	Nitrogen 5	
		100		86	147
Nitro. associated with oxygen in air,		149		560	
		560			

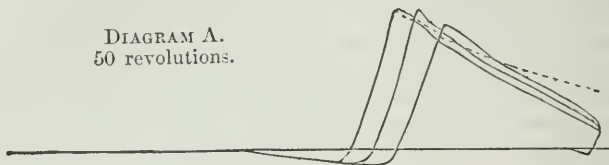
Original gases, ... 809 yield products of combustion, 793.

We see from this that for the perfect combustion of gas of ordinary quality we must supply seven volumes of air for each volume of gas, and that for gases containing a greater proportion of hydro-carbons

a greater quantity of air will be required, and, at the same time, the bulk of the products of combustion will be greater.

By applying a Richard's indicator of unusually delicate workmanship the writer obtained from an engine of $8\frac{2}{3}$ inches diameter of cylinder, and $16\frac{1}{4}$ ins. stroke, diagrams of which the accompanying is a fair specimen.

DIAGRAM A.
50 revolutions.



In this case as the explosion did not occur immediately on the closing of the valve, the tension of the gases falls to 11 lbs. per square inch, (above a vacuum.) After combustion it rises to 48 lbs. The temperature necessary to produce this pressure is found by the formula,

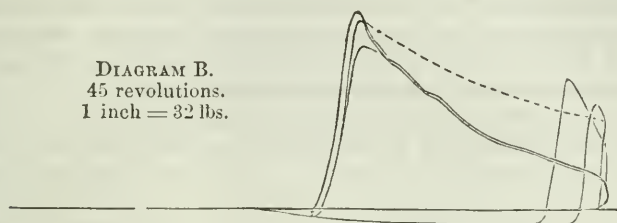
$$t_2 = \frac{P_2 \left(1 + k (t_1 - 32^\circ) \right) - P_1}{P_1 k} + 32^\circ,$$

in which t_1 = temperature of the gases before combustion, taken at 200° on account of the warmth of the cylinder.

P_2 is 48 augmented in the proportion $\frac{809}{793}$ and the mean co-efficient of expansion k of the gases under constant volume is .00204. This gives us as the temperature of the gases at the moment of combustion 2474° . The dotted line represents the theoretical curve of expansion, taking into account the loss of heat and consequent fall of pressure due to the work done, (which is the proper theoretical curve for an indicator diagram.) The temperature at the end of the stroke indicated by this line would be 2156° . The actual final temperature shown by the diagram, supposing there to be no leakage, is 1438° , and the difference, 718° , is the quantity of heat absorbed by the water jacket with which the cylinder is surrounded. It will be observed from this card, that the explosion takes place so late in the stroke that there is a considerable available pressure in the cylinder at the end of the stroke, which, of course, is not utilized. To prevent this waste, the manufacturer of these engines in this country, Mr. Miers Coryell, sets the admission valve so as to close earlier; and this has the further advantage, that at the middle of the stroke a given quantity of work is performed in less time than at the ends, and consequently there is less loss of heat.

The diagrams give information which may be of interest to some as to the time required for the explosion of such a mixture of gases. In this case it appears to be about $\frac{1}{27}$ of a second.

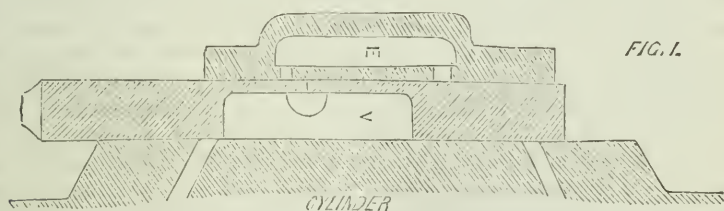
Diagram B was obtained on one occasion when the electrical points in the cylinder were wet, and owing to the uncertain passage of the spark the explosions were very irregular. It is introduced here to show the difference between explosions occurring at the middle of the



stroke and those nearer the ends. It will be observed that the pressure attained in the later explosions rises somewhat higher than the true expansion curve drawn from the point attained by explosion near the middle of the stroke, (which, as for this purpose, there is no work to be taken into consideration, would stand at the end of the stroke 4.2 lbs. higher than that shown.)

This is probably due to the greater heat acquired by the gases before explosion. It will also be noticed that the time of acquiring the maximum pressure is considerably greater in the later explosions, being $\frac{1}{30}$ of a second in the earlier and $\frac{1}{20}$ or more in the later.

Lastly, the great loss of pressure by cooling is strikingly shown—in equal times the lines fall below the height due to expansion alone by an amount proportionate to the pressure that the gases would have



at 32°. In the early explosions in this diagram, the pressure rises from 13 lbs. before explosion to 60 lbs. after, corresponding to a temperature of 3090°. The dotted line represents, as before, the true expansion curve, including the loss of 420° of heat and resulting diminutions of pressure due to the work done.

The construction of these engines is simple, differing in but few particulars from an ordinary horizontal steam engine. The cylinder and heads, as has been intimated, are cast hollow and kept cool by a current of water passing through them. The gas and air are admitted by a slide valve shown in Fig. 1. The gas pipe is connected to the chamber E bolted to the cylinder, and between which and the cylinder the slide valve V moves. The gas passes through the small port shown in the back of the valve into the semicircular channel which covers it, and through this up and out of the valve into the atmosphere. It

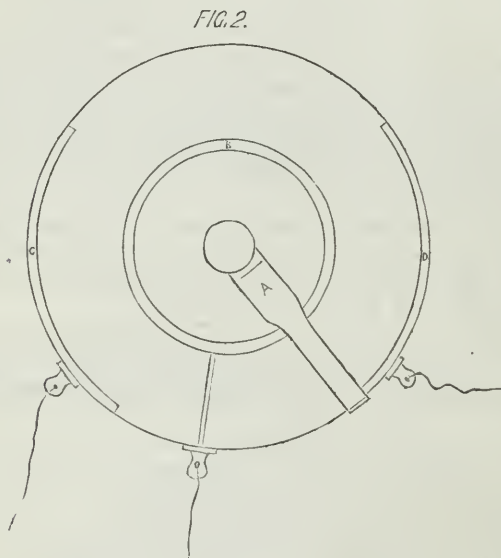
is then drawn down again by the suction of the piston through a number of small holes into the cup of the valve, and thence into the cylinder. This insures its thorough mixture with the air, while, at the same time, it prevents the possibility of explosion, since there is nowhere any explosive mixture except in the cylinder and cup of the valve, the latter being in open communication with the atmosphere.

An air chamber with openings, regulated by a slide, is placed over the holes in the valve to control the admission of air.

A separate valve on the other side of the cylinder is used for the exhaust. As constructed in the French engines this part is a weak

point on account of the great heat to which it is subjected from the escaping gases. In the American engines, a small current of water passes through this valve and entirely removes this difficulty.

The spark for igniting the gas is supplied by a Bunsen's battery of one or two cells, and a Ruhmkorff coil giving from 100 to 150 sparks per second. It is distributed to each end of the



cylinder by an arrangement shown in Fig. 2. An arm A insulated on the end of the shaft conducts the spark from the insulated ring B in connexion with the coil alternately to the segments C and D connected by wires to the respective ends of the cylinder. This arm is set so as to touch the proper segment just as the admission valve closes.

To most persons it would probably appear that the great heat generated in the cylinder would be destructive of the surfaces. The writer, however, examined an engine that had been running regularly for a month, using in that time less than a quart of oil, and was surprised to find that the bore of the cylinder and the piston rod, though dirty from deposits of impurities, were not even scratched.

The explosion of the gas is unattended by any noise unless the connexions are slack. The only size as yet constructed in this country is $4\frac{5}{8}$ inches diameter of cylinder by $8\frac{3}{4}$ inches stroke, though engines of larger dimensions are in process of construction. A friction dynamometer applied to one of these gave the following result:

Length of lever, ...	4 feet.
Weight applied, ...	7 pounds.
Revolutions per minute, ...	185
16,280 foot-pounds per minute = $\frac{1}{2}$ horse power.	

In France there are engines of 3 horse power and upwards, but with the exorbitant prices of gas in this country, 1 or 2 horse power is probably as high a power as could economically be obtained from this motor. These engines have the advantage that the expense ceases immediately with the work, which is an especial recommendation where the work is intermittent. They can be started and stopped instantly by merely turning the gas cock. They are absolutely free from danger and do not require the attention of an engineer; hence for small powers they are cheaper than steam. On account of their safety, they are admissible in situations where steam would not be.

Dry Dock Iron Works, New York.

Retardation of Electric Waves in Submarine Telegraphic Lines.

From the London Mechanics' Magazine, December, 1865.

In a paper on electric conduction, from the pen of Mr. John James Waterson, which appears in the new number of the "*Philosophical Magazine*," that gentleman reiterates the opinion, which he expressed in a paper on the same subject some few months ago, that voltaic electricity is conveyed solely by the *surface* of the conductor, and not, as is ordinarily taught, by the entire thickness thereof, and proposes a "crucial experiment" for the purpose of ascertaining whether or not this opinion is in accordance with the fact. The proposed experiment would consist in measuring, by means of M. E. Becquerel's apparatus, the conducting power for voltaic electricity of an iron wire plated with copper, and that of a copper wire coated with tin. Mr. Waterson believes that the copper-coated iron wire would be found to conduct as well as a copper wire of the same thickness, and that the tinned copper wire would be found to conduct no better than a tin wire of the same dimensions, and that it would thus be established that voltaic electric conduction is a purely surface phenomenon. Should this prove to be the case, Mr. Waterson is of opinion that it would be found practicable to avoid the retarding effect of induction in submarine cables. "The mere covering of gutta percha upon a wire," he remarks, "does not cause retardation. The presence of a conducting medium on the outside of covered wire is also necessary. Hitherto experiments seemed to have been confined to iron and water as the outside conductors. So far as I know, the effect of copper as outside conductor has not yet been tried. Iron has one-sixth or one-seventh the conducting power of copper; water only about a thousand millionth. Electric conduction as a whole depends on the freedom of motion allowed to the force as a whole. *The induced current should thus have the same freedom to move as the primary.* Practical considerations would probably require that the outside copper conductor should be insulated; so that, to make the trial effectively, it would be necessary to connect the outside coating (of woven thin copper wire) with

one pole of the battery, while the other pole led to the central wire. At the signal end, of course, there must be a similar arrangement, and this would give to the induced current the same propelling force as the primary, and utilize the half of the power of the battery that is now lost by putting to earth." Further on he insists that it is essential that the outside and the inside conductor should be of the same metal, and that his proposed arrangement "would exclude earth-currents; and if the signal house, as well as the shore end of the cable, be iron covered, it is difficult to see how atmospheric electricity could intrude upon the signals." It certainly seems desirable that this gentleman's theories should be practically tested.

On the Hydraulic Properties of Magnesian Limes. By MR. F. CRACE CALVERT.

M. H. Ste. Claire-Deville read to the Academy the following note by Mr. Calvert:

"In September, 1862, I was employed by the directors of the Dinorben Company, which is working the magnesian limestones near Am-luch, in the island of Anglesea, (N. Wales,) to ascertain whether certain beds of magnesian limestones, existing at Port Cynfor and at Hells-mouth Bay, could be practically used. After some preliminary trials, I satisfied myself that certain beds could be advantageously used; some as hydraulic cement, others for hydraulic lime, others for stucco.

"In order to learn the cause of their different hydraulic properties, I analyzed several, with the following results:

	Hydraulic Cement. Carigeract.	Hydraulic Lime. Port Cynfor.	Stucco. Hellsmouth.
Carbonate of Magnesia, . . .	61.5	55.23	15.86
" Lime, . . .	21.41	33.99	72.23
" Iron, . . .	8.76	3.85	3.21
Silica, ...	5.58	5.58	{ 2.70
Alumina, ...	2.07	2.27	
Organic matters and water, .	1.10	3.40	

"These facts show that the degree of hydraulic property of these magnesian limestones is in proportion to their content of carbonate of magnesia.

"I compared with the greatest care the degree of hydraulic property of the products of these minerals with those of the best cements and hydraulic limes in England, that is, with the best quality of Portland cement and the lime obtained from the blue lias limestone, and I obtained results which were completely identical, although these stones are in composition very different from the former.

"Like M. Deville, I observed that it was necessary to take the greatest care in the calcination. The temperature must be gradually raised to a red heat, and kept there until all the carbonic acid is driven out;

for if they are exposed to a higher temperature, a compound is formed of the lime and magnesia, or a change in their molecular condition, which renders them unfit for use. I also remarked, that after calcination they ought to be reduced to a very fine powder. The more finely they are powdered the more tenacious and homogenous they become under water."

In presenting this note to the Academy, M. H. Ste. Claire-Deville remarked, that it was evident at first sight that the hydraulic properties of the cement analyzed by M. Calvert were almost entirely due to the exceptional quantity of magnesia which that dolomite contained. Five per cent. of silica would not be sufficient to give such energetic hydraulic properties to a pure limestone. But it must be remarked, that this small quantity of silica was of essential service in these circumstances. It prevents the lime from becoming injurious in case a too high heat of calcining should introduce it into the cement; for, upon recalling my former communication, and paying attention to the last lines of Mr. Calvert's note, it will be remarked that in a magnesian cement the lime must remain as a carbonate so as not to be injurious. If we calculate according to the excellent data of MM. Rivot and Chantonay, the quantity of lime which the silica and alumina can transform into a hydraulic material, and add to the alumina the oxide of iron produced by the calcination of the carbonate contained in the Carigeract stone, taking account also of the observations of M. Malaguti, we see that this hydraulic material must be composed of—

Silica,	.	.	.	.	.	.	.	.	5 6
Alumina,	.	.	.	.	.	.	.	.	2·1
Sesquioxide of iron,	.	.	.	.	.	.	.	.	6·
Lime,	.	.	.	.	.	.	.	.	6·7

So that of the 12 per cent of lime which an overheated calcination of this limestone might give, but 5·3 remain caustic, the influence of which on the setting of the magnesia is altogether insensible.

So that the good qualities of the Carigeract cement, so well established by Mr. Calvert, are due: 1st. To 29·1 per cent. of caustic magnesia, which can solidify a considerable quantity of inert material, and 22 to 20 per cent. of the hydraulic matter of ordinary cements, which would be absolutely inefficient in a limestone to make cement, but which add their action to that of the magnesia.

Proc. Acad. Sciences of Paris.

*India Rubber considered in reference to its Applicability as an Insulator for Telegraphic Conductors.** By WILLIAM HOOPER.

From the London Civil Engineer and Architects Journal, December, 1865.

The difficulties which have preceded the successful issue of india rubber insulation are precisely the same which were encountered for many years after the introduction of this substance as a branch of manufacture. Native or raw india rubber, when in good condition,

* Read before the British Association.

may be kept for years without sustaining any deterioration, but in certain stages of its manufacture it becomes susceptible of decay, which is accelerated by exposure to air and light. The decay of india rubber is now well known to be the result of oxidation, and is characterized by a gradual tendency to fluidity; its first stage of decay is recognised by a diminution of its elasticity, and by its becoming glutinous or sticky, and finally being reduced to a tarry-looking fluid, which state it always preserves.

The ultimate composition of india rubber is represented by the formula $C_8 H_7$. The analysis of Dr. Miller accords, with tolerable exactness, with this formula. He found in 100 parts 85.82 carbon and 11.11 hydrogen. The sample which he analysed, however, contained 3.07 oxygen, and evidently could not have been pure caoutchouc. Neglecting the oxygen, the composition of pure caoutchouc, as reduced from its empirical formula ($C_8 H_7$), is 84.56 carbon and 12.33 hydrogen, the difference in which from the results by Dr. Miller's analysis is practically nothing, and confirms the accuracy of the original analysis.

India rubber in its manufactured state contains more or less of its oxidised product, which produces the color recognised in this substance, pure caoutchouc being colorless. The word caoutchouc should properly be applied to that pure principle of carbon and hydrogen which forms the greater part of manufactured india rubber.

The process by which india rubber is rendered suitable for the purposes of insulation, consists of an operation which involves its partial oxidation, and unless this oxidation is arrested, the india rubber becomes useless as a permanent insulator. India rubber when thoroughly washed and dried is masticated, by which means it becomes highly colored, and is afterwards found to contain a variable amount of its oxidised product. By mastication, the india rubber is converted into solid masses or blocks, which are cut up into slabs or sheets; the sheets are again cut into tapes, which is the only form for applying it to telegraphic conductors. The tapes being put on the wires, another operation is required to reduce them into a perfectly uniform and solid covering. This has been usually effected either by the use of solvents or the direct application of heat, both of which plans are seriously objectionable. By the application of solvents, the india rubber becomes more susceptible of oxidation, whilst the direct application of heat induces a molecular change more favorable to its oxidising. Wires insulated by either of these means, indicate a very high state of insulation when first made, but as the india rubber decays the insulation is reduced, and ultimately destroyed.

About two years ago five lengths of india rubber insulated wires were supplied to the government for submersion in the Persian Gulf, which, with the exception of one, have failed almost entirely. I was favored with a report from government a few weeks ago, made by Mr. F. C. Webb, from which it appears that the length remaining perfect is, at the temperature of 75° Fahr., three times better than the gutta percha insulated wires which form the core of the Persian Gulf cable.

Mr. Webb stated in his report that he did not know who were the respective manufacturers of these several lengths, but he brought home a piece cut from each length for identification. On my calling upon him, he placed several pieces before me, and I had no difficulty in recognising my manufacture. Mr. Webb at once said that it was off the length which he had reported to the government as being the only one that remained perfect. It will be seen from these numbers that it is the highest degree of insulation yet practically attained. A length of 1610 yards, tested under a pressure of 6000 lbs. per square inch, and the same length, tested again under a pressure of 4480 lbs. per square inch, maintained for nearly eighty hours, showed an increase in its insulation resistance; and on removal of the pressure it was not found to have diminished, as has been stated to be the case with some specimens of india rubber insulated wire. The length under this test contained two joints. The high results obtained from joints in my insulated wires have entirely removed all apprehensions on this important point, and there is no practical limit to the age of the material in which joints can be safely and reliably made. Five miles of my insulated wire, containing in each case eight and twelve joints, were uninterruptedly maintained at the temperature of 75° and 95° Fahr., respectively, for 240 hours, and on being reduced to the initial temperature were found to have suffered no permanent change.

The facilities offered by my process for producing insulated wires of nearly identical degrees of insulation, and for reducing the most minute fault, enable me to bring forward this system as one by which absolute freedom from defects can be insured. This is a point intimately connected with the success of submarine telegraph cables; for it frequently has happened that minute faults have, on submergence, enlarged into sources of serious annoyance. The central position of the conductor is unaltered by any elevation of temperature, and as it maintains a high degree of insulation at 150° Fahr., or even higher temperatures, it is peculiarly applicable for tropical seas. In its resistance to mechanical injury it far surpasses all other materials which have been tried for insulating telegraphic wires. The low inductive capacity of india rubber renders it especially suitable for telegraphic cables, and by my process the low induction of india rubber is maintained.

Sir Charles Bright, Mr. Latimer Clark, and Professor William Thomson have favored me with the details of some very interesting investigations which they have gone through, on the qualities of my insulated wires, and, as Professor Thomson was not aware that Sir Charles Bright and Mr. Latimer Clark were giving their attention to the subject, it is highly satisfactory to find how nearly they agree in reference to the inductive capacity compared with gutta percha. Prof. William Thomson found the induction of my wire, as compared with that of gutta percha, to be as 100 to 135, while Sir Charles Bright and Mr. Latimer Clark found it as 100 to 136. Mr. Wildman Whitehouse examined a length of one of my higher insulated wires, which he found as 100 to 160. As the rate of signalling is governed by the

retardation arising from inductive charging, the transmission of messages will be inversely as these numbers; that is to say, that 135 to 160 messages could be sent through an Atlantic cable by using a conductor insulated with india rubber according to my process, whereas 100 only could be sent in an equal time by using a conductor insulated with gutta percha. This has a most important bearing in a financial point of view, since the cost of insulation by my method would not be greater, and in some of its forms considerably less, than that paid for insulation by gutta percha.

(Several lengths were shown to the sections, and also a diagram illustrating the effects of temperature as compared with gutta percha.) The mathematical properties of the curve were, for the temperatures determined on my core, similar to those obtained with gutta percha, but the differences in the insulation for increase of temperature were not so great as are observed to take place with gutta percha.

The following table gives the insulation resistance in millions of B A units of my core and gutta percha, at different temperatures:

	0° Cent.	24° Cent.	38° Cent.
Gutta percha, (Persian Gulf core,)	3205	170	45
Mr. Hooper's core, ...	71036	6328	2283

A length containing a joint that had been kept in a boiling solution of salt (220° Fahr.) for twenty hours, was placed in a vessel to be again heated to that temperature and tested, but the committee decided that it was unnecessary to test it, or any of the specimens and joints exhibited.

The specimens and joints had been made at different periods during the last four years, and were shown for the purpose of being examined, to see that they had not suffered any change. Amongst the specimens was a length of a half a mile with a joint cut from the five miles referred to above.

During the discussion which ensued,

Mr. Siemens, F. R. S., expressed his concurrence with Mr. Hooper's remarks on the value of india rubber insulation, as compared with that of gutta percha, except that india rubber improves in insulation under pressure. With that exception, he considered that Mr. Hooper had kept within rather than gone beyond their relative properties. Difficulties had hitherto been found in the application of india rubber as an insulator, and it would be interesting to the section to know how Mr. Hooper had overcome them.

Mr. Fleeming Jenkin, F. R. S., stated that he had for some years been acquainted with Mr. Hooper's method of insulation by india rubber, and he had never seen a length of his manufacture that indicated loss or decay. He considered the difference between the result of testing under pressure by Mr. Siemens and that by Mr. Hooper was caused by Mr. Hooper's process in consolidating the india rubber; his experience tended to confirm the statements made by Mr. Hooper. He thought it exceedingly desirable that Mr. Hooper's cable should be practically tested by being submerged and worked, as it was evident that for long lengths and tropical seas, it seemed to possess very valuable properties as compared with gutta percha.

Mr. Gassiot, F.R.S., said he thought the experiments in connection with the submergence of the two Atlantic cables had demonstrated that the two mechanical difficulties of the task could be overcome with a moderate degree of care and attention, and the most important consideration was that it had been demonstrated possible to lay a cable between Ireland and Newfoundland, but they must take care and not do as had been done in other cases, viz: lay down a cable which would only last two or three years. In this connection, Mr. Gassiot pointed out the importance of the cable produced by Mr. Hooper, although he questioned if the time had arrived for a final experiment in the laying down and working of an Atlantic cable. He thought the bearing of india rubber in its various qualities as an insulator ought to be satisfactorily and conclusively determined before the laying of another cable was attempted. If they went on from year to year unsuccessfully, they would absorb any amount of capital, and the citizens to whom they must go for material support would close their purses, whereas, if they only waited the result of the experiments being diligently prosecuted by electricians, they would be able to come forward with a scheme which would not only be a success, but practically with the best cable. There would then be no difficulty in raising capital, for there was no doubt that the Atlantic Telegraph would be laid, but before again embarking on the enterprise every experiment should be made. This was the only prudent and safe course to adopt. He understood the government had sent out, two or three years since, several lengths of insulated wire by different manufacturers to Kurrachee, including one by Mr. Hooper, to be practically tested by submersion in the Indian Seas, and a report had been lately furnished to the government stating that all of them, except the length supplied by Mr. Hooper, had failed. The report to government went on to state that Mr. Hooper's cable tested three times better than the Persian Gulf cable, which is insulated with gutta percha; the government had, in consequence, given Mr. Hooper an order for about fifty miles of his cable, to be supplied forthwith. He considered the Atlantic Company might well follow the example set by the government.

Electric Light for Light-houses.

It would seem that the substitution of the electric light in light-houses does not present so much advantage as had been anticipated. At a lecture delivered upon the subject by M. Leroux, it was stated that the electric light on Cape La Héve (near Havre) gave a light equal to 125 standard burners, (carcel 0.8 inches diameter, burning 617 grains of colza oil per hour,) and cost 3.84 cents per burner per hour. The oil lamp gave a light equal to 23 standard burners, and cost 1.52 cents per burner per hour. (Experiments made upon a smaller scale, but probably with more precision, at Paris, give as the ratio of the cost of equal lights by electricity and by oil $\frac{3.75}{1.00}$.) The useful effects do not appear to be in proportion to the expense. Thus when the standard

light was visible only at a distance of 2 kilometres, (1½ mile,) the oil lamps in the Fresnel lantern showed the light, when fixed, at 3 miles, when revolving, at 3·7 miles. Under the same conditions the range of the electric light was 3·6 and 4·2 miles. The difference is not commensurate with the excess of expense. It is true that in case of foggy weather the intensity of the electric light may be with more facility increased, but this would lead to a very serious inconvenience of having a light of irregular intensity, and thus preventing mariners from judging correctly their distance from it.

Force of Insects.

Borelli, La Hire, Regnier and others have determined, with more or less care, the ratio between the weight of certain animals and their muscular force. According to Regnier, a man is capable of drawing 0·86 of his weight; a horse can draw only 0·67. (This is the weight lifted by the force of draught.) M. Felix Plateau has recently published a very valuable series of experiments upon the drawing, pushing, and flying forces of different insects, which we judge to possess interest and curiosity enough to justify us in publishing an abstract of them.

Drawing force.	Mean ratio of weight drawn to weight of body.	Drawing force.	Mean ratio of weight drawn to weight of body.
Carabus auratus, .	17·4	Anomala frischii, .	24·3
Nebria brevicornis, .	25·3	Oryctes nasicornis, .	4 7
Necrophorus vespillo, .	15·1	Geotrupes stercorarius, .	9·8
Silpha livida, . .	24·4	Onthophagus nuchi-	
Ocypus morio, . .	17·0	cornis, . .	14·4
Quodius fulgidus, .	29·6	Apis mellifica, . .	20·2
Cetonia aurata, . .	15·0	Cicindela Hybrida, .	12·1
Trichius fasciatus, .	41·3	Donacia nymphæa, .	42·7

These numbers are almost regularly in the inverse ratio of the size of the insect.

PUSHING FORCE.

Oryctes nasicornis, ...	3·2
Geotrupes stercorarius, ...	16·19
Onthophagus nuchi-	
cornis, ...	79 6

FLYING FORCE.—Measured by the ratio of the weight with which the insect could fly, to the weight of its body.

Neuroptera, .	{ Aeschene grandis, ...	0·79
	{ Libellula vulgata, ...	1·01
	{ Lestes sponsa, ...	0·71
	{ Agrion pupilla, ...	0·74

Hymenoptera,	{	Bombus terrestris,	0.63
		Apis mellifica,	0.78
Diptera, . .	{	Eristalis tenax,	1.48
		Syrphus corollæ,	1.84
		Calliphora vomitoria,	0.93
		Musca domestica.	1.77

As these insects are all European, we are obliged to keep their scientific names, noting only that *apis mellifica* is evidently the honey bee, that *libellula* is a dragon-fly, probably not the same as ours, and that *musca domestica* is the European house-fly, whether the same as others we do not know, but hope that it is not a greater nuisance.

On Deaths by Lightning.

Extract of a note by M. Bondin, Academy of Sciences of Paris, November 27, 1865.

In the course of the year 1864 the number of persons in France who died from the immediate effect of lightning was 87, of whom 61 were males, 26 females. In 1863 the number was 103. In the period from 1835 to 1864 it was 2311 for the 86 old departments of France, and adding 120 (or 4 per year for each of the 3 new departments), we get for the present France, for a period of 30 years, a total of 2431 deaths by lightning. We believe that we have shown, by a great number of facts, that the number of persons wounded by lightning is at least four times that of those killed immediately, the only category reported by the government. Hence, it results that from 1835 to 1864 the total number of killed and wounded was 12,000, or a mean of 400 victims per year.

During this period the proportional number of persons killed varied exceedingly from one department to another. The ratio in *Lozere* was 31 times greater than that in *La Manche*. In the table which we present showing the distribution of the 87 deaths by lightning in 1864, the most striking result is the very unequal distribution between the two sexes, only 26 females for 61 males. From 1854 to 1864, inclusive, there were recorded 967 persons killed, of which 698 were males and 269 females, from which it would seem that only the small proportion of 28 per cent. of those killed by lightning are females. In England, the proportion is only 22 per cent. This comparative immunity cannot be attributed to greater exposure of men out of doors; for it exists even among children less than 15 years old, among whom the ratio of female deaths is only 16.6 per cent., and we may add that, in a great number of cases in which the lightning fell among groups of persons of both sexes, there was a decided immunity shown for the female sex.

Experiments and Observations on the Oxidation of Vegetable Oils.

By M. S. CLOEZ.

In a third memoir upon this subject, read to the Academy of Sciences of Paris, M. Cloez announces the following results of his experiments and observations :

1. That all the fat oils absorb oxygen from the air, and increase in weight by quantities which differ for different kinds of oil placed under the same circumstances, and for the same oil under different circumstances.

2. That the height of the temperature exercises a very marked influence on the rapidity of the oxidation.

3. That the intensity of the light also manifestly influences the phenomena.

4. That light transmitted by colored glasses checks more or less the resinification of the oils by the air. Starting from colorless glass as the term of comparison, the decrease of oxidation is in the following order: Colorless, blue, violet, red, green, yellow.

5. That in darkness the oxidation is considerably retarded; starts later and progresses more slowly than in light.

6. That the presence of certain materials, and the contact with certain substances, accelerate or retard this effect.

7. That in the resinification of oils there is both a loss of carbon and hydrogen of the oil, and an absorption of oxygen.

8. That the different oils, in oxidizing, furnish in general the same products: volatile acid compounds, liquid and solid fat acids not altered, and an insoluble solid material, which appears to be a definite proximate principle. Oils oxidized in the air no longer contain glycerine.

9. The drying and non-drying oils are not chemically distinguishable. All contain the same glyceric proximate principles, but in different proportions.

Graphotype.

From the London Mechanics' Magazine, December, 1865.

At the meeting of the Society of Arts held on December 6, Mr. H. Fitz-Cook read a paper on a new method of producing from drawings blocks for surface printing, without the aid of the engraver, to which the name of "Graphotype" has been given, and last week's number of the Society's *Journal* contains some illustrations printed from blocks produced by the new method. The new process is the invention of Mr. De Witt Clinton Hitchcock, one of the foremost draftsmen and engravers of New York, and was suggested by a little incident which Mr. Fitz-Cook thus related: "In the summer of 1860, Mr. Hitchcock, in the course of making a drawing on box-wood, found it necessary to alter a portion of his design by erasing it and rewhitening the exposed surface of the wood. The material used for this purpose was the enamelled surface of an ordinary visiting card, softened by water and a brush,—a method known to most draftsmen on wood. The card employed happened to be one printed from a copper plate, and after the removal of all the enamelling, as described, the artist discovered that the printed letters were undisturbed, and standing up in bold relief." His first attempt to carry out the idea, which this circum-

stance instantly suggested to him, was made upon a slab of chalk, sawn from an ordinary lump, and on one surface made as smooth a possible by scraping. He drew upon the smoothed surface of this piece of chalk with ink and a quill pen, using as ink silicate of potash, or "water glass," colored with indigo, and when the lines of the drawing were dry, he brushed away, by means of a tooth-brush, (but not using water, as when removing the enamel from a card,) all the portions of the chalk surface upon which there were no lines. "The lines of the drawing," we are told, "being literally composed of stone, withstood the assault of the tooth-brush, but the intervening particles of exposed chalk succumbed and vanished in a cloud of snowy dust, leaving the impregnable lines standing in relief, inviting a proof of their strength by printing on paper. This could not be done until the whole mass of chalk was changed into stone, by saturating it with the liquid glass, but in half an hour the chalk block was inked and printed in the ordinary way by burnishing." Ultimately, as the result of a great number of experiments, Mr. Hitchcock elaborated a process which seems likely to supersede wood engraving, if not for all, at least for many purposes, being much cheaper than wood engraving, and having, moreover, the great advantage of infallibly reproducing the artist's every touch, however delicate, with the most perfect accuracy. In its present shape, the process is conducted as follows: An artificial chalk block or plate is first produced by grinding the best French chalk to fine powder, mixing this powder with water to a thin cream, and separating the portion which precipitates first, repeating this operation several times in order to ensure the complete separation of any hard or coarse particles, drying the very finely divided chalk thus obtained and sifting it through wire-cloth, having 10,000 holes to the square inch, on to the surface of a perfectly smooth plate of zinc, placing a plate of highly polished steel on the top of the even layer of chalk flour thus obtained, and then submitting it to powerful hydraulic pressure. On removing the pressure and lifting off the steel plate, the chalk is found to be firmly attached to the zinc plate, and to present a perfectly smooth upper surface, which only requires to be "sized," in order that the ink to be used in drawing on it may not "spread," to be ready for the artist. The latter proceeds as in the ordinary method of drawing on wood, first making a red chalk tracing on the block or plate, and then, with sable hair pencils of various sizes, drawing his design line for line, exactly as he wishes it to appear when printed. The ink used is a mixture of glue and lamp-black, and dries instantly, so that one series of lines, of whatever thickness, may be immediately crossed by others. The drawing being completed, the portions of the chalk surface intervening between the lines of the drawing are disintegrated and removed, to the depth of an eighth of an inch or so, by means of brushes, some of them of fitch hair and others of silk velvet, and the chalk block is then hardened by being soaked in a solution of an alkaline silicate. A mould is then taken from the chalk block, and a type metal cast produced from this mould, by the ordinary processes of stereotyping, and it is this type metal

cast, and not the original block, that is used to print from. "The process is so delicate," says Mr. Fitz-Cook, "that the impression of the thumb wetted with the graphotype ink, skeleton leaves, feathers, and other objects of which nature printing has been applied, can be made to give beautiful impressions in the ordinary type press, whilst the finest hair line that the artist can make will stand equally well with the bolder work." The type metal cast may be obtained with ease within three hours after the completion of the drawing on the chalk surface, so that the new process has an immense advantage over wood engraving, not only as regards cost, but also as regards the time occupied between the completion of a drawing and that of the block by means of which copies of it may be multiplied by the printing press. While thus cheap and expeditious, the new process reproduces the artist's work with an absolute accuracy unapproachable by the most skilful engraver.

On the Decay of Gutta Percha and Caoutchouc. By Prof. WILLIAM ALLEN MILLER, M.D., F.R.S.

From the London Artizan, December, 1865.

Continued from page 131.

3. *Experiments on submarine cables.*—I have examined several specimens of cable from different lines which have been submerged for periods of time varying from a few weeks to seven years. In no case where the cable has been completely and continually submerged have I found any sensible deterioration in the quality of the gutta percha.

No. 1. Holyhead Irish cable, (from Captain Galton,) taken up in February, 1859, after seven years' submergence.

No. 2, *a, b, c.* Three specimens from the Dutch line, from Orfordness to Schevening, (Mr. L. Clark,) submerged five years, raised in August, 1859.

This cable was enclosed in a coating of galvanized iron wire, and contained a single wire of copper in gutta, bound round with hemp and tape soaked in boiled linseed oil, tallow, and Stockholm tar.

a. External coating of galvanized wire, not damaged by corrosion. This sample had been buried on the Dutch coast to a small depth in sand.

b and *c.* Outer galvanized wire much corroded, but the gutta percha quite sound. The gutta percha wire had, in each of these samples, been exposed to the air, out of the metallic casing, for some months, and consequently was dryer than the sample *a*, taken from its metallic coating just before it was analyzed.

No. 3. Cable off Portland, (Captain Galton.) Down for seven months; composed of seven thin copper wires twisted into a strand, covered with tar, then coated with gutta percha, without any metallic protecting envelope.

No. 4. Cable from line between Candia and Alexandria, (Captain Galton.) Construction similar to the last; it showed superficial erosions of the gutta percha after submergence for a few weeks, but the composition of the gutta was unchanged.

No. 5. New gutta percha covered wire, (Mr. L. Clark,) never used. The only chemical difference perceptible in these different specimens was in the quantity of water mechanically retained in each. 100 parts of each contained—

	1	2			3	4	5
		<i>a</i>	<i>b</i>	<i>c</i>			
Water, . . .	0.84	3.36	1.75	1.49	4.80	0.96	2.50
Ash, . . .	1.05	. . .	. . .	0.76	3.52	0.75	0.50

4. *Experiments upon damaged cables, suspended in air or placed underground.*—Of damaged cables I have had various specimens for examination.

1 to 6. Six examples described by Mr. Saward in his evidence before the Committee, January 12, 1860.

1. Buried in chalky or gravelly soil, coated with a white, friable crust of altered gutta percha. This was very brittle, and contained 35 per cent. of resin; this resin contained 17 per cent. of oxygen combined with a hydro-carbon of the same composition as pure gutta.

2. Was in soil exposed to leakage of gas pipes, and also was resinous and brittle, but less so than No. 1.

3. Was described as pulpy when raised, as if fermenting; taken from ground into which drainage from oak trees or posts occurred. When forwarded to me it was hard and tough, the copper wire within was slightly corroded and adhered to the gutta percha, the channel around the wire lined with a pale brown powder. This powder contained traces of copper. It appears to consist of gutta percha, as it was almost wholly soluble in benzol and was insoluble in alcohol. The material in this case seemed to have undergone comparatively little permanent change, although so very different in appearance from ordinary gutta percha, when it was taken up. It fused below 212°. It had been painted with some pigment containing lead, and on burning left an ash amounting to 1.87 per cent.

4. Not very brittle, taken from iron pipes.

5. Exposed to a dry heat near a baker's oven; coated with red lead.

6. Exposed to a dry heat, (exact source not indicated.) This was extremely brittle, could be powdered without difficulty, and was almost converted into a resinous substance. It fused below 212°, it left 1.03 per cent. of ash when burnt, and appeared to have been coated with some pigment.

In all these samples those which were most brittle contained the oxidized resinous body in largest proportion. This resinous substance varied somewhat in the proportion of oxygen which it contained in the different samples, but presented the same general properties. It was soluble in cold alcohol, and still more largely in boiling alcohol; was

insoluble in ether, and but sparingly in benzol; diluted alkaline leys dissolved it with facility, and the solution coagulated on the addition of an acid in excess.

7 and 8. Samples of gutta percha covered wire taken from a tunnel in the Stour Valley, placed in the tunnel in 1850, (Mr. L. Clark.) One portion of this, A, was comparatively little injured; the other, B, was brittle and rotten. This sample had been coated with some pigment containing lead.

It would be useless to cite in detail the various analyses which I have made of these several samples, or to give the numbers obtained for the proportion of moisture, ash, and resin which they contained, or to quote the proportions of carbon, hydrogen, and oxygen ascertained to exist in the altered portion, as contrasted with the unchanged portion, present in each sample.

It may be stated generally, that wherever the proportion of resin was greatest, the sample of gutta exhibited the greatest degree of brittleness; and this brittleness was always found to be most marked in the specimens which had experienced the greatest degree of oxidation; and further, that these changes appeared to occur most rapidly and decidedly in those points where the gutta percha was alternately wet and dry.

5. *Experiments on Caoutchouc.*—The caoutchouc of commerce is, like gutta, not a pure vegetable principle, and consists of a hydrogen composition, mixed with a small quantity of resin, the amount of which varies in different specimens.

The following are the results of my analysis of a sample of pure unmanufactured para rubber, compared with a sample of good sheet masticated or manufactured rubber:

	Virgin.	Masticated.
Pure caoutchouc, ...	96.60	96.64
Moisture, ...	1.30	0.82
Resin, ...	1.80	2.06
Ash, ...	0.30	0.48
	100.00	100.00

Or, deducting moisture and ash, its elementary composition gave:

	Virgin.	Masticated.
Carbon, ...	85.82	85.53
Hydrogen, ...	11.11	12.06
Oxygen, ...	3.07	2.41
	100.00	100.00

Caoutchouc, like gutta percha, is, as already stated, liable to deterioration by exposure to the action of oxygen in the presence of solar light, but the gum is less rapidly injured if exposed to their influence in the native state, than if it had been previously masticated. When subjected to the action of air excluded from light, it does not experience any marked change, even during very long periods. It is, however, important to observe that the masticated rubber is much more porous than the unmanufactured caoutchouc. When immersed in water, caoutchouc absorbs a much larger quantity of this liquid than gutta percha, and the masticated much more than the unmanufactured

or virgin rubber. I subjoin the results of my examination of some samples submitted to experiment by Mr. L. Clark.

A.—*Virgin para rubber, finest quality*.—500 grains of this was exposed in each experiment, in the form of a narrow tape-like strip of rubber, which had been stretched while hot and suddenly cooled. It was of a very pale brown color. The various samples were submitted to experiment at the end of October, 1859, and were examined nine months afterwards, (August 4, 1860.)

No. 1, which had been exposed in netting in the open air to sun and rain, had become blackened and rotten, but was neither sticky nor crumbled; had increased in weight 34·5 grains, or 7 per cent.

No. 2 was exposed to the air and light, but kept dry in a bottle placed mouth downwards; it had increased in weight 14 grains, or 2·8 per cent., by absorption of oxygen, and had become brown, soft, and sticky, especially in the parts most exposed to light. It gave up 11·81 per cent. of an oxidized, soft, and viscous resin in alcohol. The annexed analysis will give an idea of the composition of the resin thus formed:

Carbon,	.	.	.	.	.	.	.	67·23
Hydrogen,	.	.	.	.	.	.	.	9·54
Oxygen,	.	.	.	.	.	.	.	23·23
								100·00

The proportion of oxygen differs a little in different samples.

No. 3, which was exposed to diffused light in fresh water in an open bottle, had become white and opaque from the absorption of moisture, and had increased 86 grains, or 17 per cent., but it had experienced no other alteration in chemical properties, and when dried resumed its original characters.

No. 4, exposed in sea-water in an open bottle to diffused light, had absorbed 3·6 per cent. of its weight of water, but was only a little altered in appearance, not in chemical composition.

B.—*Masticated rubber, sheet, best quality*.—A similar series of experiments were made simultaneously upon masticated sheet caoutchouc.

No. 1, exposed to sun and rain, had collected into a sticky mass, which had lost its tenacity and elasticity.

No. 2, in the inverted bottle exposed to diffused light and air, had increased in weight 8 grains, or 1·6 per cent., and had collected into a lump, which was viscous, and had lost its elasticity, especially in the parts most exposed to the action of light. When treated with alcohol it was found to yield 12·64 per cent. of its weight of resinous matter to this solvent. These changes were in marked contrast to No. 3, which was kept in a glass bottle in the dark for the same period, but exposed to the air freely. It had increased in weight only 0·6 per cent., did not show any sign of alteration in tenacity or elasticity, and yielded to alcohol 2·0 per cent. of resin only.

No. 4, a sheet of the same rubber immersed in fresh water, open to the air and diffused light, had increased 87 per cent. by absorption of water; that is to say, it had nearly doubled its weight. It had become

white, opaque, slimy, and sticky when pressed, and allowed water to be squeezed out by pressure. It lost weight rapidly by drying when exposed to the air.

No. 5, similar to the last, but exposed in sea-water. It was slightly opaque and slimy, but had increased only 5 per cent. in weight by absorption. A second sample, in sea-water in a closed bottle, emitted a smell of sulphuretted hydrogen, and had gained 5.6 per cent. in weight by absorption. Its elasticity and tenacity were not impaired. The gradual permeability of masticated caoutchouc to water was further strikingly shown by enclosing a quantity of acetate of potash in bags made of sheet rubber and accurately sealed. They were then immersed in water, and at the end of nine months the salt in each of the bags was found to have become liquefied by the water which it had absorbed, and the bags had in each case gained in weight several grains.

C.—*A similar series of experiments made with sheet rubber, vulcanized.*—1. The sheet exposed in the netting to the sun and rain had lost 2 per cent. in weight; it was scarcely less tenacious than at first.

2. A similar sheet in fresh water absorbed 19 per cent., but was not otherwise altered.

3. A similar sheet in sea-water was rather more slimy, and had only gained 1.6 per cent. in weight.

Each of the three substances, viz: natural, masticated, and vulcanized rubber were submitted to the action of the following solvents for nine months:

- A. Boiled linseed oil.
- B. Unboiled linseed oil.
- C. Stockholm tar.

The *virgin rubber* had resisted the action of the solvents almost perfectly, retaining its toughness, excepting in those parts which were above the surface of the liquid and exposed to light. In the tar, this rubber had contracted spontaneously, but was still strong and elastic.

The *masticated rubber* was, in each instance, greatly swollen and gelatinized, and indeed, in the case of the unboiled oil, was completely dissolved.

The *vulcanized rubber* had also lost its tenacity, and had become swollen and gelatinous, but retained its form and a certain degree of elasticity.

A sample of india rubber cable (from Captain Galton,) which contained six strands of copper wire, each coated with rubber, then bound round with tape and again with rubber, had experienced a singular change, having become, *where in contact with the wire*, quite glutinous and sticky. This change, however, did not progress in the specimen which I kept for some months in my room, but the viscosity, on the contrary, gradually diminished.*

* The quantity of viscous matter was too small to admit of satisfactory analysis. I ascertained, however, that no copper was present in the viscous mass, and that the wire was not corroded. I could not determine whether grease was present in small quantity, as was not unlikely.

6. *Experiments on other substances.*—An insulating mixture composed of gutta percha, shellac, and powdered glass or clay, known as "Wray's Compound," (from Captain Galton,) was also submitted to experiment.

Heated to 212° it softened, but retained its shape. It lost by drying 0.5 per cent. of moisture, and when burnt left 22 per cent. of a white ash, chiefly silicate of alumina. This compound absorbs water but sparingly. 500 grains left in fresh water for six months increased 7.5 grains in weight, or 1.5 per cent., and a similar increase in weight occurred in another experiment where *sea-water* was used.

Sample of gutta percha cable (from Captain Galton) vulcanized by Mackintosh's patent.—The wire was found to be blackened on its surface from the action of the sulphur, owing to the formation of sulphide of copper, and traces of copper were found in the gutta percha covering.

On some of the most Important Chemical Discoveries made within the last Two Years. By Dr. F. CRACE CALVERT, F.R.S., F.C.S.

LECTURE I.

From the London Journal of the Society of Arts, No. 671.

On the Discoveries in Chemistry Applied to Arts and Manufactures.—In this lecture I intend to treat of chemistry applied to the arts, and more especially to some of the discoveries which have been made within the last two years. Many of these will appear to you to be incomplete, but if complete they would not be new, for seldom are discoveries perfected at once. They are generally the result of many years study, and of the thoughtful consideration of several men.

The first part of this lecture will have reference to some of the applications which the laws of light have received during the last few years; and it will, I hope, convince you of the necessity of every one engaged in the arts making himself acquainted with all the laws connected with the phenomena of light, to enable him to appreciate the discoveries which have been made, or to assist him in improving upon those which are already known, as they are constantly receiving the most valuable applications in the arts and manufactures. Thus, for example, M. Donné has applied the properties of light to ascertain the relative values of milk by the amount of cream they contain, and this he effects by an instrument which he calls the lactoscope. Dubosch Soleil has applied with great success one of the most complicated laws of light, viz: polarized light, to the commercial estimation of the various qualities of sugars. By this process the sugar refiner, or any other person interested in that product, is enabled to ascertain in half an hour exactly the amount of crystallized sugar there is in a given sample, as compared with the quantity of non-crystallizable, or what is commonly called treacle. M. Dubosch Soleil's apparatus is considered so accurate that the French government has adopted it to determine the value of raw sugars imported into the country, and the

customs duties are levied upon the results given by this instrument. I may further add that this apparatus, called "Polarizing Saccharometer," is based on the peculiar property which light has when polarized, or when its rays are received at an angle of $35^{\circ}25'$ degrees on a plate of tourmaline or a mirror. M. Dubosch Soleil's apparatus enables him to work with polarized light, which presents the various colors of the spectrum in such away as to enable him thereby to determine, as I have already stated, the amount of crystallizable sugar in any given quantity of the article, sufficiently accurately for all commercial purposes.

It is impossible for me, in a single lecture, to attempt to give you an idea of the various improvements which have been effected, even within the last two years, in the arts of photography, talbotype, photozincography, glyphography, or other processes which are due to the action of light on sensitive surfaces; but you will find an excellent paper on the application of photography, and also of light to sensitive surfaces as applied to the art of engraving, in vol. xiii., page 131, of this *Journal*, by Mr. S. T. Davenport, under the heading of "Engraving and other Reproductive Art Processes." Still there are two discoveries which appear to me to deserve passing notice, viz: the carbon process of Mr. Swan, and also the process discovered by M. Villème, and now carried on in London by a company, by which the operator is enabled not only to take the photograph of a person, but to produce a statuette giving a full representation of the figure itself, and a far more accurate personification than could be produced by any sculptor, and that at a cost of as many shillings as the sculptor would expect pounds. But the most important series of researches which have been made of late years in connexion with photography, and to which I deem it my duty to call especial attention, are such as to acquire more and more importance as they are more developed. I therefore feel convinced that any one who will devote his talents to the study of this particular branch of photography, will in time be amply rewarded, and of this there can be no doubt, when we consider the results already obtained by the labors of only two or three gentlemen. I refer to the reproduction of the various colors of the spectrum upon sensitive surfaces. In 1838, Herschel was the first to publish a paper on the various colors which chloride of silver is susceptible of taking under the influence of certain colored rays of light. Mr. Robert Hunt also published, in 1840, a paper referring to the subject; but the most complete series of researches on the subject of the reproduction of the colors of the spectrum, and which led to a process by which several of the colors of the spectrum could be reproduced on a sensitive surface, is due to Edmond Becquerel. The results arrived at by this gentleman were so remarkable that they drew the attention of the whole scientific world; and the following is an outline of the processes which were applied by him to obtain this interesting result. He took a daguerreotype plate or a silver-plated one, and having dipped it in a weak solution of chlorine, or, what was still better, a weak solution of hydrochloric acid, by connecting it with the poles of a battery, the

brilliant silver surface acquired different tints, passing gradually from an opaque white to a black tint. He also observed that the tint best suited to obtain favorable results was when the plate had acquired a pearlish pink; and although he found that the plate so prepared, when placed in the camera obscura, assumed the colors composing the spectrum, still they were faint, but he remedied this defect of intensity of tints by heating for several hours to a temperature of 95° to 100° the chlorinated plate, and then submitting it to the influence of the various colors composing the spectrum. Further, in the course of his studies he made the important observation that he could replace the peculiar action of heat on his prepared daguerrotype plate by exposing it to the rays of the sun under a sheet of paper which had been steeped in an acid solution of sulphate of quinine. The effect of this was that the plate of silver assumed an intense white color, nearly resembling that of paper; whilst if the protective paper had not been used, the silver plate would have gradually acquired a dark tint, and would have lost the whole of its sensitive properties, the protective paper having the power of arresting completely the most refrangible rays of light, especially those which are beyond the line η of the spectrum. Notwithstanding M. Edmond Becquerel's ardent hopes to find a method which would enable him to fix on a sensitive surface the various colors of the spectrum, still he failed, for they faded immediately after they were exposed to the direct rays of light, and could only be preserved in obscurity. But there is one gentleman who deserves great praise for the extraordinary perseverance which he has shown in this class of investigation. I mean the nephew of the discoverer of photography, M. Niépce de Saint Victor. Although I will not enter here into the details of these valuable researches, as they can be found in the *Comptes Rendus de l'Académie des Sciences*, still I may just be allowed to state that he has not only, by the following process, obtained far more brilliant colors than those first produced by M. Becquerel, but has succeeded in reproducing on sensitive plates the various colors of colored surfaces, such as are presented by fabrics, flowers, &c., and further, he has lately been so fortunate as to reproduce on his plates, yellow and black tints, which had resisted all previous attempts. To give you an idea of the facts arrived at by this gentleman, I may state, that he has succeeded in so fixing upon sensitive surfaces the various colors of the spectrum, or of colored surfaces, that they will bear the action of diffused light for several days. In fact, I have seen photographs, which reproduce faithfully, a small doll dressed up in various colors, and in which even the most minute ornament could be traced, and, what is certainly not less interesting, was the reproduction of the iridescent colors of the peacock's feather. To obtain these marvellous results, M. Niépce de Saint Victor takes a daguerrotype, or silver coated plate, and dips it into a weak solution of hypochlorite of sodium, having a specific gravity of 1.35, until it has assumed a bright pinkish hue. The plate is then covered with a solution of dextrine, saturated with chloride of lead; it is then dried, and subsequently submitted to the action of heat, as in M. Becquerel's experiment, or under the

screen of sulphate of quinine also referred to above. The plate is then ready to be placed in the camera obscura, and to receive the colors of the spectrum, or representations of nature, such as flowers, as well as certain colors produced by man. Lastly, he succeeds in increasing the stability of the colors developed on the sensitive surface by covering the plate with an alcoholic solution of gum benzoin, and M. Niépce gives the name of Helio-chromie to this branch of photography.

During his lengthened researches, M. Niépce de St. Victor has made two series of observations which I deem it my duty to lay before you, viz: that he can produce with facility, on prepared plates, the binary colors of the spectrum, viz: orange, violet, indigo, and green, if those colors are natural; but if they are artificially produced by the mixing of two of the primary colors, as red and yellow, or orange and blue, and yellow or blue, he cannot produce the binary color, but only one of the two colors employed by the artisan to prepare them. Thus, for example, he can reproduce the natural green of malachite, and the beautiful color known as Scheele's green, but he cannot do so with a mixture of Prussian-blue and yellow chromate of lead, the blue only reappearing. These facts enable him to explain why, in ordinary photography, the leaves of plants always appear black, and why, when he attempts to fix on his plates the colors of leaves, they have a bluish hue, the yellow portion of the color not being reproducible.

M. Niépce has made another series of observations which deserve notice, viz: that when a plate, as prepared by his process, is dipped in an alcoholic solution of substances susceptible of imparting a color to flame, such, for example, as strontia, which communicates a red hue to it, or baryta, which gives a yellowish-green color, the prepared plates, when exposed in the camera, will assume the same color as the salt which they have on their surface would impart to the flame of alcohol; and if a salt of copper be used, which has the property of communicating a variety of tints to the flame of alcohol, the plate also will assume a variety of tints when exposed to the action of light; and during a certain period of his lengthy researches M. Niépce availed himself of this curious phenomenon to obtain colored plates in the camera. They are not only interesting as reproductions of art, and as a feat of extraordinary skill in the progress of photography, but they are especially so because in time they will lead to methods which will enable us to communicate to our little children perfect and correct views of our time, and other interesting facts connected with the period in which we live.

All persons interested in the progress of photography will find full details of the new processes for reproducing vitrified photographic plates in vol. lx., page 1239, of the *Comptes Rendus de l'Académie des Sciences*, 1865. These I omit, as they are purely technical, and have only an interest for those immediately engaged in that branch of the photographic art.

I shall now have the pleasure of calling your attention to a most important series of researches published by Professors Bunsen and

Roscoe; but, to enable you to appreciate their value, it is necessary that I should make the following remarks: It is now well known that the solar spectrum is composed of three primary colors—blue, yellow, and red; and, also, of four complementary or binary colors, viz: orange, green, indigo, and violet. It is also known that those colors represent different properties or qualities of that universal fluid called ether, which, I may say, was generalized by Sir Isaac Newton under the name of gravitation, on which the whole of the planetary system is based, and which gives to the universe its harmony and stability. This fluid is susceptible, under certain influences, as those generated by the sun, of being set in vibration, and thus are generated heat, light, and chemical rays; and further, as there is no chemical action without a corresponding production of electricity, it follows that electricity, as well as magnetism, may be considered as a mere modification in the vibrations of the same fluid. Therefore we may truly say that all the imponderable fluids called light, electricity, heat, magnetism, and force have all the same origin, namely, the fluid called ether and which, according to the nature of the vibration, develops or renders palpable to our senses one of those fluids. In fact, I feel convinced that this unique fluid is not converted into those divers fluids by special modifications of its own vibrations, but that they only become manifest to our senses when it has imparted its own or special vibration to the particles of matter, and that it is the peculiar vibration which it imparts to the molecules of matter that develops in the molecules themselves such a mode of vibration as gives birth to what we call light, electricity, magnetism, heat, and force. In fact, there is no doubt, from the researches of Dr. J. P. Joule, Professors William Thomson, Mayers, and others, that heat and force are the same fluid, for Dr. Joule has given us the exact measurement of that force. He has demonstrated that the amount of heat necessary to raise one pound of water one degree in temperature, would, if applied mechanically, be competent to raise one pound weight 772 feet high, or it would raise 772 pounds one foot high. The term "foot-pound" has been introduced to express in a convenient or systematic way the lifting of 772 pounds to the height of one foot. Thus the quantity of heat necessary to raise the temperature of a pound of water one degree being taken as a standard, 772 foot-pounds statute, is what is called the mechanical equivalent of heat. Dr. Tyndall in his valuable work on "*Heat considered as a Mode of Motion*," gives many interesting examples of the conversion of heat into force, and *vice versa*. For example, he cites the following theory of Professor Thomson, who assumes that an immense amount of force is converted into heat when meteoric matter is attracted to the surface of the sun by the molecular attraction called gravitation; that the force generated by the immense velocity with which meteoric matters travel towards the sun, becomes converted instantly by its contact with the sun into heat; and further, he considers, that the showering of meteoric matter, as well as that of the zodiacal lights on the sun's surface, are sufficient to account for the immense heat which he supposes the sun's surface to

possess. I must say that I do not believe the sun possesses much heat or light; I believe that it is only an immense mass which, by its size as compared with the rest of the planetary system, becomes the centre of gravitation; and that there exists between it and the planetary bodies a constant state of attraction; that the fluid called ether, which represents the force called gravitation, is in a constant state of activity throughout the universe, and brings about that Godly and admirable harmony which pervades it; and although the ether filling space can be considered in a constant state of action or vibration, and convertible into the fluids which we call heat, light, electricity, and magnetism, still these fluids only become manifest to our senses when they put into vibration the particles of matter, or produce, according to their peculiar vibration, the phenomena of light, electricity, magnetism, heat, and force; for if heat is convertible into force, as asserted by the researches of the eminent *savants* above stated, why should not the production of other fluids be due also to similar phenomena? If it be true, as Joule, Thomson, and others contend, that force and heat are due to the vibration of the molecules of matter, and that according to the rapidity of the vibrations of such atoms (imparted to them by the vibrations of ether) one or other of these forces is engendered, why should not the manifestations of other fluids be traced to similar causes? In fact, no doubt can exist in my opinion with respect to electricity and magnetism, for if their manifestations to our senses were owing to the vibration of a universal force, it would affect all bodies in the same way and in the same degree. Now, this is not the case; for there are good and bad conductors. Therefore it follows that the atoms composing matter, or more so, their nature, have an influence on its degree of manifestation. The same with magnetism; for we find oxygen to be magnetic, and nitrogen non-magnetic or diamagnetic. Thus it appears to me from these facts, which might be multiplied if time permitted, that the manifestations of heat, force, electricity, and magnetism are not peculiar and distinctive fluids, but are due to the modification in the mode of vibration of the universal fluid called ether, which imparts to matter its peculiar undulations, and that these forces are only made manifest to us when the vibrations come into contact with solid matters, such as compose the atmosphere or the earth. Therefore, I am of opinion that there is no light, heat, electricity, or magnetism beyond the limits of the atmosphere which surround the earth; but that when the ether, which is in a state of vibration, comes in contact with the particles of matter composing our atmosphere, it then communicates one of its own peculiar vibrations to these particles; then they, by their vibrations, become luminous. If this theory is correct, it follows that the production of the phenomena of light is due to the vibrations of solid matter, and not to the vibrations of the ether, as is assumed by the philosophers of the day.

I very well know that these views of mine are completely in contradiction with those entertained by most of the philosophers of the day; but still I hope to be able to publish a sufficient number of scien-

tific researches, as well as to draw attention to such a number of physical, chemical, and astronomical facts as may, even if not proving the truth of my views, at all events, I hope, deserve some attention.

Now, let us return to the subject under consideration, viz: that a spectrum is produced by the decomposition of light when it is refracted at an angle of 60° ; and that the result of that decomposition is the production of three primary and four binary or complementary colors. Further, that the red portion of the spectrum represents calorific rays of light; that the green and yellow represent light-giving rays, and violet and the rays beyond it the chemical or actinic rays of the same. Philosophers have for a long period been able to measure accurately the intensity of the heat-giving rays, by means of a thermometer or the thermo-electric pile; and though we had a general knowledge of the intensity of the chemical rays of light, still we had no method of accurately measuring its real intensity, and conveying our results and observations to others, till Professors Bunsen and Roscoe filled up this important gap. These gentlemen's researches will be of great service to science and to society, as they will throw much light on many meteorological data, and enable a chemist to study with more precision than has been previously done the chemical phenomena of vegetation and other phenomena connected with the chemistry of agriculture. For example, the thermometric observations giving the mean monthly or yearly temperature of a country, by no means yield all the data required for the estimation of the true climatology of the place, or of its plant or animal producing capabilities. For these purposes we require to have not only the amount of solar heat directly or indirectly reaching the spot, but likewise the amount of chemical active solar light which may be present there. This is strikingly exemplified by the following example given by Dr. Roscoe on a comparison of the mean annual temperature between Thorshawn, north latitude, $62^{\circ} 2'$; west longitude, $6^{\circ} 46''$; temperature, $45^{\circ} 6'$; and Carlyle, north latitude, $54^{\circ} 55'$; west longitude, $2^{\circ} 58''$; temperature, $46^{\circ} 9'$; difference 1.3 . From these figures it will be seen that the mean annual temperature is nearly equal, but the quantity of sunlight falling upon those two places differs most widely, and we have a corresponding difference in true climatological results. Thus the flora of the Faroe Islands and the Shetland Islands is of a most limited description. Only hardy varieties of shrubs, and no trees or flowers, exist there, while at Carlyle we have a luxuriant vegetation accompanying a most sunny sky. How essential, then, are the rays of light to vegetation. These gentlemen have also ascertained that those rays are in ratio with the intensity of that light; and still further, they are also in ratio with the chemical or actinic rays of the sun; and thus the researches of these savants will enable them to measure with accuracy those chemical actions. It is impossible, in a lecture like this, to render justice to their researches; therefore I must refer those who wish to consult them to the *Philosophical Transactions of the Royal Society*. Still I may state that these gentlemen's photochemical instruments are based on the following data, namely, that

equal intensity of light produces in the same given space of time equal shades of tint on surfaces prepared with chloride of silver of uniform sensitiveness. Thus it is shown by experiments that a tint attained by paper so prepared is constant when the quantity of light falling upon it also remains constant. Light of an intensity of 50° falling upon a paper for the time of one minute produces the same blackening effect as light of the intensity of one falling upon it for the time of 50 minutes. Knowing these laws which regulate the degree of shade of the paper, and having a surface of a perfect constant degree of sensitiveness, it is easy to obtain the absolute measurement of the chemical action of light.

(To be continued.)

For the Journal of the Franklin Institute.

Official Preliminary Report of the Results of the Trial on Long Island Sound between the U. S. Steamers Winooska and Algonquin.

GENERAL INSPECTOR'S OFFICE, }
 STEAM MACHINERY, U. S. NAVY, }
New York, February 19, 1866. }

SIR: The undersigned, appointed by you to conduct the experiments with the competitive machinery of the U. S. paddle-wheel steamers *Winooska* and *Algonquin*, have the honor to submit the following preliminary report of the results of the trial on Long Island Sound for maximum power of machinery and speed of vessel, and for economy of fuel under these conditions. It will be followed by a full report, embracing the results of all the experiments at the wharf, as well as that on Long Island Sound, together with our conclusions from the same, and all the data *in extenso*:

The trial on Long Island Sound was intended to embrace eight consecutive double runs between Execution Rock Light-house and Faulkner's Island Light-house, passing around both. Each double run, measured on the vessel's track, was, according to the Coast Survey Chart, one hundred and thirteen (113) geographical miles; but a violent storm, accompanied with weather so thick as to prevent the lights from being visible beyond a mile or two, and the refusal of the pilots to run in it, terminated the trial after the *Winooska* had performed three (3) double runs, or 339 geographical miles, and the *Algonquin* two double runs, or 226 geographical miles. Our data and results are, accordingly, for these distances, respectively. Both vessels ran a portion of the distance on the next run, but that portion is omitted because the exact position of the vessels could not be determined when it was decided to anchor.

During the running time the water was smooth and the wind a gentle, variable breeze. At each terminus of the route a large field of ice was encountered, whose resistance greatly lessened the speed of the vessels while passing through it, and their speed was also decreased

by the turning of the vessels around each terminus. Neither vessel steered well, but they were about equal in this particular, which, of course, still further lessened their speed.

The machinery of both vessels was in excellent order; that of the *Algonquin*, after the completion of the wharf trials, had been for two months and a half in the hands of the contractor for repairs, during which he had renewed all the vertical tubes of the boilers, substituted a new circulating pump, etc., etc. In the course of the trial the feed pump, worked by her main engine, was inoperative ten and a half ($10\frac{1}{2}$) hours, during which time the boilers were supplied by the auxiliary steam pump. As, however, this pump drew the feed water from the hot well, its substitution in no way affected the performance of the machinery. The counterbalance of the eccentric broke during the trial, but its fracture was not of the least importance. A paddle on one of the wheels was also broken, but it took place on the return of the vessel to port, and not during the trial.

With the machinery of the *Winooska* there were no accidents or derangements, and it functioned throughout with the same regularity, noiselessness, and smoothness of motion, which characterized its previous performances at the wharf.

On board the *Algonquin* the blower was used, but as it delivered the blast into an open fire room, its effect must have been very small. The steam jet in the smoke pipe was in use, and, with the boiler pressure of nearly 68 pounds per square inch above the atmosphere, was doubtless very efficient in forcing the draft.

On board the *Winooska* the blowers were not used. They are two in number; each is driven by an independent steam cylinder, and delivers its blast into the ash-pits of the boilers, which are closed by air-tight doors. When employed, an enormous rate of combustion can be commanded, and a supply of steam much exceeding that used during the trial. A steam jet (the duplicate of the *Algonquin's*) in the smoke pipe was employed during the trial with a boiler pressure of 38 pounds per square inch above the atmosphere.

The machinery of both vessels was fitted with surface condensers, and neither was obliged to "blow off" during the trial. The vacuum in the *Algonquin's* condenser was less than that in the condenser of the *Winooska*, but as it resulted from inefficiency of condensing surface, and not from air leaks, it was attended by a correspondingly high temperature of feed water, which, to a great extent, compensated this disadvantage.

At the commencement of the trial the *Algonquin's* draft of water was 8 feet 5 inches forward, and the same aft; while the *Winooska's* draft of water was 8 feet 10 inches forward, and 8 feet 8 inches aft. The difference of 4 inches in the mean draft was an allowance made for the deeper false keel of the latter vessel, both vessels being presumed to be in other respects identical, as they were constructed from the same building directions and mould loft dimensions.

The paddle-wheels of the *Winooska* consisted each of twenty-four (24) paddles. Each paddle was 9 feet in length and 16 inches in

breadth, and its outer edge was placed at the distance of 12 feet from the centre, making the diameter over the paddles 24 feet. The total area of paddle surface in one wheel was 288 square feet. With the vessel at the above draft of water, the deepest immersion of the outer edge of the paddles was 3 feet 6 inches.

The paddle-wheels of the *Algonquin* were arranged by the contractor as he desired. Each wheel consisted of thirty-six (36) half paddles, eighteen on each side, and placed opposite the interspaces of those on the opposing side. These half paddles would have been equi-spaced had each wheel consisted of forty eight of them instead of thirty-six; but, by the omission of twelve, six at diametrically opposite points, an empty space equal to that due to three paddles so spaced was left at those portions of the circumference of the wheel. All the half paddles were of the same length, namely, 5 feet, but they were of unequal breadths, being so made and arranged on the circumference of the wheel for the purpose of producing a regular rotary motion with the high pressure steam and high measure of expansion used. The breadths of the consecutive half paddles in inches were as follows, namely: 15, 17, 19, 21, 24, 27, 24, 24, and 21. The length from outside to outside of a pair of half paddles was 9 feet, caused by their overlapping one foot at the centre. The total area of paddle surface in one wheel, taking the length of a pair of half paddles at 10 feet, is 320 square feet; and taking their length at 9 feet, 288 square feet. The inner edge of all the paddles was at the same distance from the centre, namely, 10 feet 8 inches, which made the mean distance of their edges 12 feet $5\frac{1}{2}$ inches from the centre, or the mean diameter over the paddles 24 feet $10\frac{3}{4}$ inches. With the vessel at the draft of 8 feet 5 inches, forward and aft, the mean deepest immersion of the outer edge of the paddles was 4 feet 6 inches.

The boilers of the *Winooska* contain 200 square feet of grate surface, and 5036 square feet of heating surface, and had no means of superheating the steam. The boilers of the *Algonquin* contained 144 square feet of grate surface, and 2678 square feet of heating surface, together with 1132 square feet of steam superheating surface in tubes. The boilers of both vessels have water tubes. In the *Winooska* they are vertical and are arranged above the furnaces according to Martin's patent, and in the *Algonquin* they are inclined and arranged in combination with the superheating tubes, according to the patent of Mr. E. H. Dickerson, who designed the entire machinery of that vessel.

Each vessel has one inclined and direct acting engine. The cylinder of the *Winooska* is 58 inches in diameter, and its piston has a stroke of 8 feet 9 inches. The cylinder of the *Algonquin* is 48 inches in diameter, and its piston has a stroke of 10 feet.

The space occupied in the *Winooska* by the machinery and coal is 67 feet 11 inches long, by the entire breadth and depth of the vessel, and in this space there is a coal bunker capacity of 9424 cubic feet. The space occupied in the *Algonquin* by the machinery and coal is 75 feet 5 inches long, by the entire breadth and depth of the vessel, and in this space there is a coal bunker capacity of 6931 cubic feet.

The weight of the machinery of the *Winooska*, exclusive of water in the boilers, is 541,718 pounds, and inclusive of the water 623,718 pounds. The weight of the machinery of the *Algonquin*, exclusive of water in the boilers, is 629,144 pounds, and inclusive of the water 701,144 pounds.

The distribution of the weights of the *Algonquin's* machinery was so excessively faulty, that when the vessel was fully stowed for sea, with her coal bunkers filled, water in boilers, etc., she had a list of 22 inches to port, giving her port paddle-wheel an immersion of 7 feet $3\frac{1}{2}$ inches, and her starboard paddle-wheel an immersion of 3 feet $7\frac{1}{2}$ inches. To bring the vessel upright there was required a weight of 73 tons to be stowed on the berth and spar-decks in the extreme wing, after the hold had been restowed in such manner as to place all the weight possible on the starboard side. This additional weight of 73 tons required to be continually trimmed as the coal was used from the bunkers; of course, it added just that number of useless tons to the vessel's displacement, and if it be added to the weight of the machinery, to which it was simply a counterbalance, it will swell that weight to 866,664 pounds.

The following are the principal dimensions of each vessel; the greatest immersed transverse section and the displacement corresponds to their drafts of water at the commencement of the trial:

Depth from lower edge of rabbet of keel to mean load-water line,	8 ft. $2\frac{1}{2}$ ins.
Length on mean load-water line from the forward side of the rabbet of stem to the after side of the rabbet of the stern post,	240 ft.
Extreme breadth on mean load-water line,	35 ft.
Displacement,	1280.78 tons.
Area of the greatest immersed transverse section,	263.85 sq. ft.

On commencing the trial in Long Island Sound, the vessels started abreast at Execution Rock Light-house, after having steamed from the Brooklyn Navy Yard to that point. The machinery of the *Algonquin* was operated by four engineers from the merchant service employed by the contractor for that purpose; the naval engineers on board merely took the data of the performance, but in nowise interfered with the management of the machinery, which was exclusively in the hands of the contractor's engineers.

During the time the machinery of both vessels was in operation, a complete steam-log of the performance was kept, in which was noted in proper columns, at the end of each hour, the number on the counter, the number of revolutions made by the engine per minute during the hour, the steam pressure in the boiler and in the main steam pipe near the engine, the vacuum in the condenser, and the position of the throttle valve, the temperature of the atmosphere on deck, of the engine room, of the fire room, of the injection water, of the discharge water, and of the hot well or feed water; also, the height of the barometer in the engine room. An accurate account was kept of the coal thrown into the furnaces each hour, and of the refuse therefrom withdrawn from the furnaces and ash-pits at the end of each watch of four hours. At the end of every half-hour an indicator diagram was taken from each end of the cylinder, and the complete data marked

on it at the time of taking, such as number of revolutions of the engine per minute, steam pressure, vacuum, &c. A naval engineer was always on watch in the fire room and in the engine room of each vessel, making two engineers to a watch.

In the table hereunto appended will be found the totals and means of all the above quantities and the calculated results therefrom.

The point at which the steam valve of the *Winooska* closed and cut off the admission of steam to the cylinder, was, measured on the main crosshead guides, 6 feet 4 inches from the commencement of the stroke of the piston on the lower stroke, and 6 feet in the upper stroke. The mean point of cutting off was, therefore, at seven-tenths ($\frac{7}{10}$) of the stroke of the piston from the commencement. As the cut-off of the *Algonquin* was not a positive one, the point of cutting off was obtained from the indicator diagrams and is the mean given by them.

The following are the guarantees of the contract for the machinery of the *Algonquin*, and it was the object of the trials at the wharf and in Long Island Sound to ascertain if they were fulfilled, and if not, to what extent they were deficient:

1. "That all the materials, workmanship, detail, and finish shall be first class."

2. "That the whole performance [shall be] of such a character as to demonstrate the satisfactory strength, reliability, practical efficiency, and durability of the entire machinery."

3. "That the variations from the specifications [those of the machinery of the *Winooska*] hereunto attached, [to the contract for the machinery of the *Algonquin*,] and forming part of this contract, are to be in the dimensions and arrangements of the cylinder and such parts as are thereby affected in the design of the valve gear, and in the type and arrangement of the boilers, and also in the surface condenser. These changes are not to increase the weight of the machinery, nor the space occupied by it, nor to decrease the weight of coal carried in bunkers within the limits allowed for the engineer department with the machinery described in the attached specifications," [that is the specification for the *Winooska's* machinery.]

4. "That if on the completion of the machinery, and a careful trial thereof, by such persons as may be directed by the Secretary of the Navy, it shall be found by them that its performance, either in amount of power developed, or in the cost *pro rata* of that power in coal, is less than those of the machinery described in the attached specifications, [the specifications for the *Winooska's* machinery,] they, the said parties of the first part, [the contractors for the *Algonquin's* machinery,] will remove it and replace it at their own cost with the machinery described in the attached specifications."

The contract for the *Algonquin's* machinery also provides that, "The entire responsibility of fulfilling the guarantees is to rest with the said parties of the first part, who will make their own working drawings, and arrange and proportion the details of the said machinery in such manner as they shall deem best calculated to secure the most successful operation."

With regard to the first and second of the above guarantees, we have to say that, in our opinion, they have not been fulfilled. The *Winooska's* machinery has worked in the most perfect manner throughout, and its performance in every particular leaves nothing to be desired for efficiency in a paddle-wheel steamer. Its durability and reliability could be depended upon for any length of cruising. Its workmanship, material, finish, accessories, and appointments, are first-class throughout. The machinery of the *Algonquin* is wanting in these particulars, and in proper adaptation for marine purposes. In style, finish, and conveniences for manipulation, and in accessories and appointments, it is much inferior to that of the *Winooska*.

With regard to the third guarantee, we find the machinery of the *Algonquin*, including water in boilers, to be 77,426 pounds heavier than the machinery of the *Winooska*, including water in boilers. This excess of weight is one-eighth of the weight of the *Winooska's* machinery. If to it be added the 73 tons of extra ballast required to keep the vessel upright on account of defective distribution of the machinery, the excess of weight for the *Algonquin's* machinery will be 242,946 pounds, which is 39 per centum of the weight of the *Winooska's* machinery. This excess of weight requires about 8 inches of draft of water to furnish the necessary displacement for it, and, of course, greatly lessens the value and efficiency of the vessel.

The space occupied in the length of the vessel by the machinery and coal of the *Algonquin* is 7 feet 6 inches greater than the corresponding length in the *Winooska*. This is equivalent to 11 per centum of the space occupied by the machinery and coal of the *Winooska*; yet, in the larger space thus occupied in the *Algonquin*, there is only 6934 cubic feet of coal bunker capacity, while in the lesser space occupied in the *Winooska* there is 9424 cubic feet of coal bunker, the *Winooska* thus carrying 36 per centum more coal than the *Algonquin*.

The contractors have therefore signally failed in fulfilling the third guarantee.

With regard to the fourth guarantee, we find that the machinery of the *Algonquin* developed only 54.29 per centum of the power developed by the machinery of the *Winooska*, and that the cost of the indicated horse power in pounds of anthracite consumed per hour with the machinery of the *Algonquin* was 18.58 per centum more than with the machinery of the *Winooska*, taking that of the latter for unity. If the comparison be made, as it properly should be, for economy of fuel, by taking the combustible matter of the coal instead of the coal itself for the expression of the cost of the power, as the per centum of refuse in ashes and clinker is an accidental and variable proportion, then the cost of the indicated horse power in pounds of combustible consumed per hour with the machinery of the *Algonquin* was 23.28 per centum more than with the machinery of the *Winooska*. In this most important guarantee for amount of power and economy of fuel, the failure of the contractors is the greatest of all, resulting in a loss of speed of nearly two geographical miles per hour, and a large increase of the cost of the steam power, *pro rata*.

In every point guaranteed by the contractors for the *Algonquin's* machinery, they have failed, and we are of opinion that it is totally unfit for the naval service.

The steam logs of the experiment and the indicator diagrams are herewith forwarded.

Respectfully submitted by, sir,

Your obedient servants,

ROBERT DANBY,
EDWIN FITHIAN,
MORTIMER KELLOGG,
Chief Engineers U. S. N.

HON. GIDEON WELLES, *Secretary of the Navy.*

DATA AND RESULTS of the trials of the U. S. Paddle-wheel Steamers "WINOOSKA" and "ALGONQUIN," on Long Island Sound, between the Light-houses on Execution Rock and Faulkner's Island, to ascertain the relative amount of power developed by the machinery of the respective vessels and the cost of the same, pro rata, in fuel.

	WINOOSKA.	ALGONQUIN.
Date of commencing trial, ...	3 PM, Feb 13, '66.	3 PM, Feb 13, '66.
Vessel's mean draft of water at commencement of trial, in feet and inches, ...	8 ft. 9 ins.	8 ft. 5 ins.
Vessel's greatest immersed transverse section, in square feet, ...	263.85	263.85
Vessel's displacement, in tons, ...	1280.78	1280.78
Mean immersion of outer edge of paddles at commencement of experiment, in feet and inches, ...	3 ft. 6 ins.	4 ft. 6 ins.
Duration of the experiment, in consecutive hours and minutes, ...	28 hrs. 53 min.	22 hrs. 54 min.
Total distance run, in geographical miles, ...	339	226
Total number of revolutions made by the engine, ...	36436	24700
Total number of pounds of anthracite consumed, ...	101490	51800
Total number of pounds of ashes and clinker from the anthracite, ...	19700	8400
Total number of pounds of combustible consumed, ...	81790	43400
Per centum of anthracite in ash and clinker, ...	19.41	16.21
Pounds of anthracite consumed per hour, ...	3513.799	2262.009
Pounds of combustible consumed per hour, ...	2831.737	1895.196
Pounds of anthracite consumed per hour per square foot of grate surface, ...	17.569	15.708
Pounds of combustible consumed per hour per square foot of grate surface, ...	14.159	13.161
Pounds of anthracite consumed per hour per square foot of heating surface, ...	0.697	0.845
Pounds of combustible consumed per hour per square foot of heating surface, ...	0.562	0.708
Number of revolutions made by the engine per minute, ...	21.025	17.977
Steam pressure in boilers, in pounds per square inch above the atmosphere, ...	38.00	67.85

TABLE, (Continued.)

	WINOOSKA.	ALGONQUIN.
Steam pressure in main steam pipe, near the cylinder, in pounds per square inch above the atmosphere, ...	34.03	64.70
Proportion of the throttle valve open, ...	0.475	Wide.
Steam cut off at from commencement of stroke of piston, ...	0.705	0.126
Vacuum in condenser, in inches of mercury, Barometer, ...	26.26 30.12	22.80 30.16
Mean gross effective pressure on piston, in pounds per square inch, by indicator, ...	34.721	28.055
Pressure of the steam in the cylinder at the end of the stroke of the piston, in pounds per square inch above zero, ...	22.50	11.53
Mean back pressure against the piston during its stroke, in pounds per square inch above zero, ...	1.71	4.35
Gross effective horses power developed by the engine, ...	1010.874	548.794
Pounds of anthracite consumed per hour per gross effective horse power, ...	3.476	4.122
Pounds of combustible consumed per hour per gross effective horse power, ...	2.801	3.453
Mean speed of vessel per hour, in geographical miles of 6086 feet, ...	11.737	9.869
Mean temperature, in degrees Fahr., of the atmosphere on deck, ...	38.55	41.00
Mean temperature, in degrees Fahr., of the engine room, ...	64.34	66.52
Mean temperature, in degrees Fahr., of the fire room, ...	90.27	98.65
Mean temperature, in degrees Fahr., of the injection water, ...	34.00	34.00
Mean temperature, in degrees Fahr., of the discharge water, ...	61.03	57.18
Mean temperature, in degrees Fahr., of the hot-well or feed water, ...	109.72	142.91
Difference between the rotary speed of the centre of pressure of the paddles and the speed of vessel, in per centum of the former, ...	20.48	22.93

Sugar.—Alvaro Reynoso's Cold Process.

From the London Journal of the Society of Arts, No. 683.

Messrs. Travers call attention to this process as follows: "Certainly no one can say that sugar manufacture is not advancing, when we have to chronicle in one year Fryer's concreter, the alcoholic process, (of which we hope to give details shortly,) and the cold process of M. Reynoso. True, neither of these inventions have as yet had any effect upon sugar making in general, but they also have not been tried. Without them, however, a point has been reached, when, with vacuum pans, centrifugal machines, *appareils à triple effet*, and other old in-

ventions and new applications, white sugar can be as cheaply made as brown, and when, were it not for the scale of duties, we should receive all our sugar in a fit state for immediate use. With regard to M. Reynoso's process, the following particulars are extracted from a paper read by that gentleman before the French *Académie des Sciences* and reported in the *Comptes Rendus* of that body. M. A. Reynoso commences by saying: 'The process for the treatment of saccharine juices, which I have the honor to submit to the Académie, is divided into two parts. 1st. Defecation. Chemists have long been occupied with the advantages that would result were aluminous substances used in sugar manufactures. Alum, sulphate of alumina, and alumina itself, in a more or less pure state, have been tried with more or less success in sugar manufactories. Evans has described in detail the way in which alum and the sulphate of alumina were used, and speaks of the good results that had been obtained in the English colonies. I myself have employed sulphate of alumina under different circumstances, but have seen that, side by side with considerable advantages, the use of this substance leads to serious inconveniences. Acid phosphate of lime has been used in Cuba since 1860, and particularly in 1863, in M. D'Aldama's works, by Mr. Swift, a distinguished American refiner, and I about that time described his process. I believe that I can now use alumina in a way to produce a defecation, perfect, from a commercial point of view, and that I at the same time succeed in eliminating hurtful substances. The substance I use is acid phosphate of alumina. After having put it directly into the cane juice, the mixture is treated with lime; free alumina and sulphate of lime are thus formed. The reactions resulting from acid phosphate of alumina, from alumina, from phosphate of lime, and from lime added in slight excess, do away with the coloring matters, azotised bodies, &c., in such a way that only a few of the salts are left that originally existed in the juice. This defecation may be compared to that produced by sub-acetate of lead, but it has not its inconveniences. 2d. Separation of the water. To evaporate the water contained in the purified juice, I employ *cold instead of heat*. I prevent in this way the numerous and complex reactions which, under the simultaneous influence of air and water, and heat coming between the different matters of which the juice is formed, cause the change in the color of the sugar. By means of a rapid cooling, produced in suitable machines, I change the juice into a magma—formed of a mixture of water reduced to the state of small pieces of ice, and of a syrup more or less dense, according to the conditions of the operation. To separate this mixture I have recourse to centrifugal machines, and I end the process by evaporating the syrup in vacuo. The details of the process will be found in my memoir.' This memoir has not yet been made public, and we shall await further particulars with some impatience. To give an opinion as to the value of the chemical part of the defecation would be premature, and it is only in practice that its value can be determined. With regard to the separation of the greater part of the water by freezing, the idea is so

simple, and yet so beautiful, that it cannot but excite admiration. It is well known that water when frozen rejects almost all alien substances, and that the ice even of a muddy puddle is pure, while the salt is driven out of frozen sea-water. Whether the cold process will pay, we cannot say, but M. Reynoso deserves every credit for the application of a well known principle to sugar making, and we may conclude by wishing that gentleman the success to which his efforts entitle him."

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, February 15th, 1866.

The meeting was called to order with the President, William Sellers, Esq., in the chair.

The minutes of the last meeting were read and approved. The minutes of the Board of Managers were reported as follows:

The Board of Managers have organized by electing Messrs. George Erety and W. Barnet Le Van curators for the ensuing year, and appointing the following Standing Committees:

1. *On Instruction.*

John F. Frazer,
Pliny E. Chase,
J. Vaughan Merrick,
Coleman Sellers,
Henry Morton.

2. *On Stocks and Finance.*

Frederick Fraley,
George Erety,
Washington Jones,
James S. Whitney,
Samuel S. White.

3. *On Elections and Resignations.*

O. Howard Wilson,
Percival Roberts,
Henry G. Morris,
Samuel Hart,
William J. Horstmann.

4. *On Publications.*

John H. Towne,
Fairman Rogers,
Henry Morton,
Coleman Sellers,
Samuel Sartain.

Donations were received from the Royal Astronomical Society and the Royal Geographical Society, London, England; the Canadian Institute of Toronto, Canada; the Mechanics Institute, San Francisco, California; the Bureau of Agriculture, Washington, D.C.; B. H. Latrobe and C. S. Smith, Baltimore, Md.; T. H. Leavitt, Boston, Mass.; and Charles E. Smith, Prof. John F. Frazer, Edward L. Wilson, and the Mercantile Library Company, Philadelphia.

The Various Standing Committees reported their minutes, and the Special Committee on experiments in steam expansion reported progress.

In default of the regular paper for the evening, a description was given, by Mr. J. Moore, of an ingenious contrivance by which the

various astronomical phenomena connected with the earth and moon, such as eclipses, phases, precession of the equinoxes, &c., were illustrated. This apparatus is called a Geoselenean.

The report of the resident Secretary, on new discoveries, inventions, &c., was then read.

SECRETARY'S REPORT.

In a paper read before the London Microscopical Society, by F. H. Wenham, some curious and valuable facts are mentioned in connexion with the cause of certain fractures in glass. If a hard body, such as a piece of iron wire, is drawn with force over a plate of glass, and the latter is inspected with a microscope employing polarized light, a mark will be observed, much like the bur made on a leather bound book, by drawing over it the edge of a paper cutter. The particles in this line are compressed, and develop a strain which, of course, tends to produce a rupture. This will account for the very common breaking of glass tubes which have been cleaned by forcing through them with a wire, a piece of cotton waste or like substance. It is the wire which does the mischief, or if a piece of cane is used, this, by reason of its hard, silicious character, is equally destructive. A piece of soft wood, or some equivalent means, should be employed.

The action of the glazier's diamond is very similar to this, and if the glass is thick and is not broken after "cutting," the compressed particles will in time disintegrate and break up along the line, producing a double furrow, as may be seen by watching the process of polishing out such a scratch.

In a previous report it was mentioned that a M. Alvergnyat had received a prize from the Société d'Encouragement pour l'Industrie Nationale, for the manufacture of Geissler tubes. At that time the Secretary had written to Mr. J. Queen, of this city, then in Europe, requesting him to obtain a set of these tubes from the manufacturer named. This had been successfully accomplished, and the large collection of tubes now exhibited was part of the assortment imported by Messrs. Queen & Co. These tubes certainly did credit to the award of the Society above mentioned, and to the skill of their constructor, being the most beautiful and even wonderful specimens of glass-blowing ever seen in this country. In some cases globes were seen within other globes, cemented, and filled with different rarefied gases. In others, spirals of glass tubes were seen within and filling globes in a manner which defied even conjecture as to the method of their introduction. The perfect regularity and precision of form in all parts was another noteworthy feature in these structures, regarding them simply in a mechanical point of view.

When the current of electricity from a Ruhmkorff coil was passed through these tubes, the effects of light and color developed were in many novel, and in all most beautiful. In the middle of one was seen a luminous emerald-green lily cup, (of fluorescent uranium glass,) into and over which streamed a flood of purple light; another contained at one end nitrogen, giving a reddish-purple light, in the middle sulphide of

carbon, giving white light in broad stratifications, each half an inch thick, which filled a globe of 5 inches, constituting the middle of the instrument; the other end, containing carbonic acid, (?) showed a rose-pink light. The different parts of the tube were united by the concentric globes before mentioned, and in these the white stratified light was broken into a starlike figure, tinged with purple in one case, and with pink in another, in a manner, the beauty of which cannot be described. Other tubes contained spirals of various forms immersed in fluorescent solutions, and developed with these every conceivable combination of colors and tints.

A set of tubes also contained some of Becquerel's phosphori, or sulphides of calcium, and of strontium variously prepared. These, after the momentary passage of the electric flash, or after exposure to daylight, continued to glow for some minutes with green, blue, and orange light.

It was also mentioned in a previous report, that very small Ruhmkorff coils had been manufactured at Paris. A specimen of these, imported by Messrs. Queen & Co., was present for inspection. The coil, with a battery to work it, and a set of Geissler tubes, was here contained in a box about the size of a common school dictionary, and could be furnished at the moderate price of \$18.

In connexion with these Geissler tubes, the Secretary would mention an observation communicated to him by Prof. Rood of New York, which might be of value to those using them. The sealed ends of these tubes were covered with cement. This was required for insulation; without it the spark would sometimes enter the tube at this point and cause it to admit the air. One of the tubes in this collection had lost this insulation, and if used without it might have been spoiled.

The receipt for Schultze's white gunpowder has been published, from which it appears that this material is simply tri-nitro-celulose, or explosive pyroxyline prepared from sawdust (which has been washed in alkali and bleached) soaked in a solution of nitre and dried.

In connexion with this, attention was called to some little packages of paper, sent by Messrs. Queen & Co., a sheet of which, crumpled in the hand, lit, and thrown in the air, burned with a brilliant colored light,—red, green, yellow, &c., without smoke or ash. These consist of paper converted into pyroxyline by nitric acid, saturated with some flame-coloring salt, such as nitrate of strontia, baryta, &c., and dried. A description of these was published in the notes to "Faraday's Lectures on the Physical Forces." They form a pretty philosophic toy.

It may be well at the present time to mention, though the observation is an old one, that if a few fragments of chlorate of potash are thrown into dilute hydrochloric acid, small quantities of chlorine, mingled with hypochlorous acid, are evolved, which act as deodorizer or disinfectant.

From a paper read before the British Association, by Dr. B. W. Richardson, we learn, as the result of elaborate investigations, that ozone is present in pure air in the proportion of 1 part in 10,000. In excess it tends to develope congestive bronchitis in carnivorous ani-

mals, but has little effect on herbivorous, and deodorizes putrefying substances, checking putrefaction.

Antozone, on the contrary, produced among other things, by the breathing of animals, promotes putrefaction and developes diseases of that character. Air, even if purified from carbonic acid, is not wholesome without ozone, and as this is destroyed by intense heat, we can readily understand the evil effects produced by allowing a furnace for warming, to become red hot.

It is announced that the two light-houses at Havre will be lit with the electric light supplied by magneto-electric machines, manufactured by the Alliance Co., of Paris.

The following Committees were appointed by the President :

<i>On Library.</i>	<i>On Arts and Manufactures.</i>	<i>On Minerals.</i>
Pliny E. Chase, John C. Browne, James Dougherty, Fairman Rogers, James S. Whitney, John Redfield, Henry Morton, J. V. Merrick, Charles Bullock.	William Adamson, John H. Cooper, Charles G. Crane, Henry R. Lawrence, C. Eugene Meyer, Jacob Naylor, Isidore Osorio, Percival Roberts, William G. Rhoads, Samuel S. White.	Clarence S. Bement, Isaac H. Conrad, John F. Frazer, Emile Geyelin, Theo. D. Rand. Robert H. Lamborn, Robert E. Rogers, John C. Browne, Richard A. Tilghman, Elias Wildman.
<i>On Exhibitions.</i>	<i>On Models.</i>	<i>On Meteorology.</i>
William J. Horstmann, Coleman Sellers, Frederick Graff, J. C. Cresson, J. Gardiner, Jr., Edwin Greble, J. Vaughan Merrick, Wm. A. Mitchell, T. Morris Perot, O. Howard Wilson.	James Agnew, William B. Bement, Edward Brown, Charles H. Cramp, Mordecai W. Haines, Addison Hutton, John Kile, W. Barnet Le Van, John L. Perkins, S. Lloyd Wiegand.	Charles M. Cresson, John F. Frazer, Henry Hartshorne, Caleb S. Hallowell, James A. Kirkpatrick, Henry Morton, James A. Meigs, Pliny E. Chase, James H. Cresson, Samuel S. White.
<i>On Meetings.</i>	<i>On Scientific Proceedings of the Institute.</i>	
Henry Cartwright, John F. Frazer, Emile Geyelin, Edward Longstreth, J. Vaughan Merrick, Henry Morton, Fairman Rogers, Coleman Sellers, Thomas Shaw, B. Henry Bartol,	John F. Frazer, J. Vaughan Merrick, Henry Morton, Fairman Rogers, Coleman Sellers.	

BIBLIOGRAPHICAL NOTICES.

Facts about Peat as a Fuel. By T. H. LEAVITT. 2d edition. Boston: 1866. 8 vo., pp. 168.

Facts about anything are always of interest to the student of nature,

and no one can say that any such may not be or become of importance in the arts. Facts in reference to fuel, in view of our present enormous consumption, and the tendency to monopolies in the supply, take precedence of those on almost any other subject in reference to their importance to manufacturers, and even to persons in general. The treatise before us presents a great number of well arranged and well expressed facts upon the subject of peat as a fuel, which we fancy will be, in a great measure, new to very many of its readers, and are well worthy of their attention. The origin and nature of peat, the modes of determining where it exists, of obtaining and preparing it for use, its general value as a fuel, and the particular circumstances under which its use appears to be especially indicated, are well set forth, and the result is a very useful and entertaining treatise, which would seem to have attracted much of the attention which it merits, since it appears that a second edition has been called for within nine months of the issue of the first.

Photographic Mosaics. Edited by M. CAREY LEA and EDWARD L. WILSON. Philadelphia: 1866. 18 mo., pp. 144.

This little work consists of a collection of small articles on subjects connected with photography, such as will be found valuable by amateur or even by professional photographers, and which would be difficult for any one to refer to as quickly as desirable unless thus collected and preserved. Several original papers by M. Carey Lea, Esq., who has earned for himself a well deserved reputation in this branch of art, and the valuable series of letters by Mr. Coleman Sellers to new beginners in the art, are added to the collection, and the whole forms a neat and handy little volume, which every photographer will find valuable to him in the prosecution of his labors.

The Celebrated Theory of Parallels.—Demonstration of the Celebrated Theorem Euclid I, Axiom 12; with appendix containing the philosophy of the demonstration, together with the partial refutation of Mr. Wm. Hamilton's philosophy of the unconditioned or infinite. By MATTHEW RYAN of County Tipperary, Ireland. Washington: 1866. 12 mo., pp. 10.

In a circular note sent with the pamphlet the author affirms that, "Besides wiping away the reproach of geometry, it acts as a barrier against atheism and infidelity." We therefore strongly recommend its attentive perusal to all whose geometry requires wiping clean from reproach, or who feel in danger of an attack from atheism or infidelity. But since its effect has been to render Bertrand absurd and Prof. Henry unphilosophical, (p. 4,) we rather incline to adhere to the Smithsonian Institute and the Coast Survey, and "shrink from expressing an opinion." Let every one read and make his opinion for himself, expressing it if he dare.

A Comparison of some of the Meteorological Phenomena of JANUARY, 1866, with those of JANUARY, 1865, and of the same month for FIFTEEN years, at Philadelphia, Pa. Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½' N.; Longitude 75° 11¼' W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	January, 1866.	January, 1865.	January, for 15 years.
Thermometer—Highest—degree, .	52·00°	51·00°	65·00°
“ date, .	13th.	10th.	29th, '64.
Warmest day—mean,	43·67	43·50	58·33
“ “ date, .	13th.	10th.	15th, '63.
Lowest—degree, .	—9·00	6·00	—9·00
“ date, .	8th.	28th.	8th, '66.
Coldest day—mean,	2·67	12·83	—1·00
“ “ date, .	8th.	27th.	9th, '56.
Mean daily oscillation,	12·52	11·90	11·97
“ “ range, .	7·20	7·14	6·57
Means at 7 A. M., .	27·47	22·85	27·76
“ 2 P. M., .	33·98	29·90	35·18
“ 9 P. M., .	29·53	26·85	31·02
“ for the month,	30·33	26·53	31·32
Barometer—Highest—inches, .	30·757 ins.	30·315 ins.	30·757 ins.
“ date, .	8th.	8th.	8th, '66.
Greatest mean daily press.	30·665	30·303	30·665
“ “ date, .	8th.	8th.	8th, '66.
Lowest—inches, .	29·565	29·141	28·911
“ date, .	13th.	7th.	23d, '53.
Least mean daily press.,	29·642	29·402	29·086
“ “ date, .	13th.	10th.	23d, '53.
Mean daily range, .	0·181	0·234	0·215
Means at 7 A. M., .	29·999	29·843	29·959
“ 2 P. M., .	29·960	29·795	29·918
“ 9 P. M., .	29·991	29·828	29·948
“ for the month, .	29·983	29·822	29·942
Force of Vapor—Greatest—inches, .	0·309 in.	0·347 in.	0·505 in.
“ date, .	20th.	10th.	11th, '58.
Least—inches, .	·024	·051	·023
“ date, .	8th.	28th.	22d, '57.
Means at 7 A. M., .	·127	·106	·133
“ 2 P. M., .	·131	·114	·149
“ 9 P. M., .	·133	·119	·144
“ for the month, .	·130	·113	·142
Relative Humidity—Greatest—per ct.,	100·0 per ct.	96·0 per ct.	100 per ct.
“ date, .	15th.	6th.	often.
Least—per ct.,	32·0	40·0	24·0
“ date, .	4th.	14th.	25th, '60.
Means at 7 A. M., .	78·3	81·1	79·7
“ 2 P. M., .	62·2	65·3	67·6
“ 9 P. M., .	77·0	75·6	76·4
“ for the month	72·5	74·0	74·6
Clouds—Number of clear days,* .	8	9	8·9
“ cloudy days, .	23	22	22·1
Means of sky cov'd at 7 A. M.,	69·7 per ct.	50·0 per ct.	62·8 per ct.
“ “ “ 2 P. M.,	56·8	65·8	62·6
“ “ “ 9 P. M.,	56·4	45·8	48·9
“ “ for the month	61·0	53·9	58·1
Rain and melted snow—Amount,	2·885 ins.	3·598 ins.	3·238 ins.
No. of days on which rain or snow fell,	7	12	10·5
Prevailing Winds—Times in 1000,	N61°3'W ·310	N69°56'W ·331	N61°38'W ·319

* Sky one-third or less covered at the hours of observation.

JOURNAL
OF
THE FRANKLIN INSTITUTE
OF THE STATE OF PENNSYLVANIA,
FOR THE
PROMOTION OF THE MECHANIC ARTS.

APRIL, 1866.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Williamsport Suspension Bridge. By ALFRED P. BOLLER, C. E.

This bridge crosses the Susquehanna River at the foot of Market Street in the above city, and at a point where the river is nearly 1000 feet wide. It was thrown open for travel during the beginning of last December, replacing the former wooden bridge which was entirely swept away by the great flood of the previous March. The whole bridge cost less than \$40,000, and its construction occupied about four months. The cables supporting the structure festoon the river, as it were, in five spans, each 200 feet in length, the intermediate towers resting upon the masonry of the former piers. The general plan of bridge is known as the "Murphy Military Suspension Bridge," embodying some marked improvements and advantages which will appear further on.

The Cables, having a common versed sine of 20 feet, consist of five wire ropes for each side, of an inch and a quarter diameter, and are continuous from anchorage to anchorage. They were hauled over from one side of the river to the other by means of a windlass, and raised to their positions on the towers by ordinary block and tackle. The whole ten were stretched over the river and adjusted to place in little less than a week's time. The ends of the cables are secured in forged wrought iron thimbles, the wires being frayed out by means of tightly driven sprags, the interstices remaining being filled with lead poured in, and well hammered. The thimbles are connected with the turn-buckles, which are 18 inches long, by means of forged inch and three quarter bolts, with eyes on one end, and swivel-heads at the

other. The turn-buckles screw upon 2 inch rods, which pass entirely through the masonry.

The Anchor Masonry is, below the line of cables and above the foundation proper, a trapezium in form, 15 feet long in the line of slope, the front face being 8 feet 3 inches high, and the back 2 feet 8 inches. Upon this slope the anchor irons, consisting of five 2 inch rods, were laid, and solid masonry 3 feet high built upon them. The uniform width of the anchorage is 8 feet. The whole masonry is built of heavy flagging stones, 6 inches thick and upwards, and is thoroughly grouted from top to bottom. Each anchoring mass contains thirty-six perches of masonry. The pressure is distributed over the masonry by means of four vertical 7 inch Phoenix beams, against which and at their centre two parallel and horizontal 9 inch beams bear, separated enough to let the ends of the 2 inch rods pass between, and cast iron washers, for the nut to be screwed up against, complete the fastening.

The Towers, 27 feet high, supporting the cables, are in the form of a frustrum of a pyramid, battering at the rate of one inch to the foot. They are built of white pine 12×12 posts, mortised at their base into sills 12×14 resting upon the tops of the piers and abutments, which sills are connected at proper intervals by ties mortised into them. The hollow spaces between the sills and ties are filled in with cement masonry. These sills are continuous, *i. e.* each pair of towers is framed into the same set of sills. The legs of the towers are stiffened by having ties mortised into them and pinned with oak pins. The caps are mortised into the tops of the posts, the shoulders of the mortise being made square with them. Resting upon these caps are the saddles, also of white pine, in three pieces; the centre one of which (16 inches deep) is bolted into each cap by one inch bolts. Each pair of towers are united together at the top by means of a 10×12 tie beam, bolted to the under side of the caps by means of the same bolts that secure the centre saddle pieces. An inch and a half bolt passes through each pair of caps for attaching the truss rods to.

The Roadway is 18 feet wide in the clear, and is attached to the cables by means of white pine posts, 7 inches square, hung together in pairs, with an inch space between them for the truss rods to pass through. These suspenders are so arranged as to divide each span into ten panels, all of which are 20 feet from centre to centre. These suspenders have a slightly greater batter than the legs of the towers, so as to slope towards the chord line of the cables when freely suspended. The cables are spread in passing over the towers, but cluster at the suspension posts, passing between them, and bear against oak saddles sunk into daps in the posts, and an inch bolt passing through both posts and saddles completes the attachment. Nine inches from their lower ends, the posts are clasped by two floor beams, 6×14 each, bolted to them, and running far enough past the posts to support foot-walks on either side. These floor-beams support the stringers, which are arranged as on Plate II.

The outside stringers are packed chords, bolted to the floor-beams, and are packed in two pieces breaking joint, each piece being 5×12

inches scantling. There is one joint for each panel, which joint is always over a floor-beam. The three inch plank that composes the flooring, is laid upon these stringers and spiked to them. *The sway or lateral bracing* is formed of $1\frac{1}{8}$ inch rods in four pieces to each panel, starting from the upper series of bolts that fasten the floor-beams and the posts together, to which they are attached by means of an eye, and through which the above described bolts pass. At the point where they would intersect they are cut off, passing into a ring of half-inch flat iron, against which the ends are screwed up and adjusted. *The truss rods* are introduced as shown upon the Plate, passing between the pairs of suspension posts, and are all of one inch round iron. For three panels each way from the towers, the tops and bottoms of the suspension posts are connected directly with the bases and tops of towers. The rods of the last panels (those that incline downwards) are secured to the bottoms of towers on their opposite sides; in other words, they pass through the nearest legs of the towers, and are screwed up against the legs on the further side. They thus act as an additional tie and stiffener for the bases of the towers. The ends of the truss rods are screwed up against oak blocks, bearing against the floor-beams and the feet of the suspension posts. In order to allow for the stretching of the cables, a camber of 12 inches for each span was framed into the bridge, and adds very much to the general appearance. It is intended eventually to put the foot-walk on, to pass through the towers and provided for in construction in the elongation of the floor-beams. The railing will be a substantial Howe truss 4 feet high. At present the bridge is subjected to a heavy amount of traffic, such as stone, lumber, cattle, &c., and it gives evidence to a surprising degree of stiffness due entirely to the peculiar system of trussing, in making the verticals act by thrust, and the diagonals by tension. This general arrangement for suspension bridges was first practised by John Murphy, Esq., C.E., over the Gauley, in West Virginia, and also at Franklin, Pennsylvania. But he used his diagonals to truss each panel separately, instead of trussing panels by attaching the diagonals to fixed points, as is the case in the above-described bridge, where the diagonals are secured to the *towers* for *six* panels out of ten in each span. *Without* the aid of the trussed railing, the effect of a heavy team passing over the bridge can hardly be felt until it strikes the span that we may be standing on, further than the slight tremor inseparable from all bridge superstructure, especially those of the suspension class. Without considerable modifications, the above construction for suspension bridges is inapplicable to spans much above 200 feet.

For the Journal of the Franklin Institute.

The Bourdon Pressure Gauge. By JOHN D. VAN BUREN, JR., U.S.N.

MR. EDITOR: I observe in the *Journal* for this month a very ingenious and plausible attempt to prove me in error as regards a note appended to my article on the Bourdon Pressure Gauge, in which I

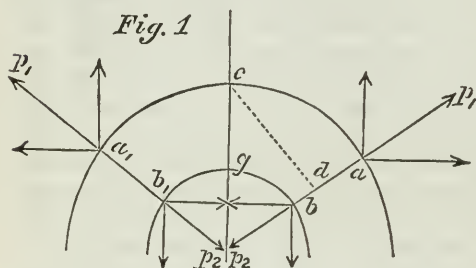
attempt to show that the principle involved in the straightening of the tube under an increased pressure does *not* depend upon the fact that the outer is greater than the inner circumference of the bend of the tube. This attempt I now proceed to prove has failed.

The writer makes his grand *faux pas* when he assumes as established the following two remarkable points:

1. That in the same system of forces, when estimating their effects upon the same body, we are at liberty to take a different centre of reference for each force.

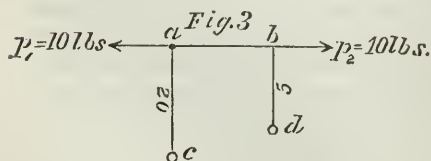
2 That the *components* of two forces will produce different effects from those of the *original* forces.

Let us refer to the figure, Fig. 1. Here we have a bent tube of circular cross-section of *invariable* size or diameter, and we may there-



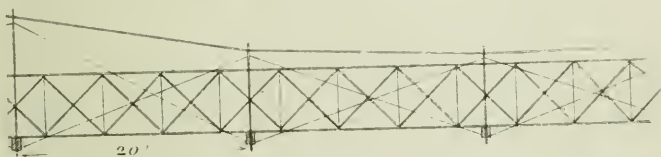
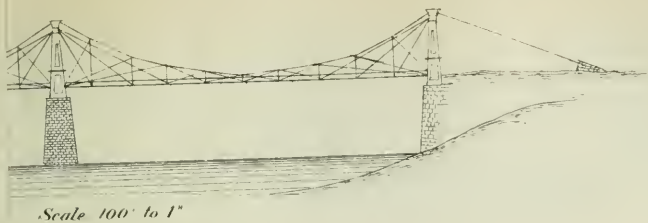
fore assume that the points *a* and *b* are *rigidly* connected by the line *ab*. Now, he proceeds to resolve the forces p_1 and p_2 into components—an entirely unnecessary operation, tending to confusion, referring the components of p_1 to the center *c*, and the compo-

nents of p_2 to the center *g*, which, by first principles of mechanics, he has no right to do, since the forces are of the same system acting upon points of the same *rigid* body, viz: the line *ab*. If the line *ab* (or, which is the same thing, the points *a* and *b* connected by this rigid line *ab*) swerve from its original position under the effect of the forces p_1 and p_2 , it must do so around a *single point* or centre, kept as it is in one plane; for there are but two possible motions, *one* of rotation and *one* of translation, and these must be estimated from a *single point* of reference, when considering the *resultant* effect of all the forces. Thus, Fig. 3, let us suppose *ab* to be a rigid line connecting the two arms *ac* and *bd*, which are pivoted respectively at the points *c* and *d*, *ac* being 20 feet in length and *bd* 5 feet in length; and that a force $p_1 = 10$ lbs. acts at *a* in the line *ab* and a force $p_2 = 10$ lbs. acts at *b* opposite to p_1 . Now, no one will pre-



tend to say that p_1 will pre-

ponderate over p_2 , simply because the *moment* of p_1 is greater than that of p_2 , when estimated after the above peculiar method—from a distinct centre? or, making $p_1 = 5$ lbs., that p_2 will *not* preponderate? But the line *ab*, Fig. 3, is under precisely the same circumstances as the line *ab*, Fig. 1; for the line is rigid, and the section *ab*, being a *circular* one, is that of equilibrium, making the elementary forces



of Half Span

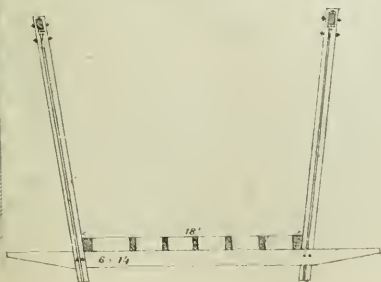


AMPORT SUSPENSION BRIDGE

1865.

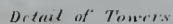
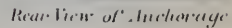
Scale 16' to 1"

H. P. Bolton
Engineer

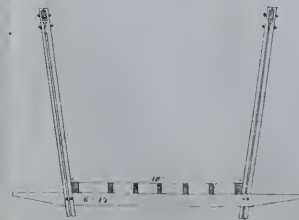




Side View of Anchorage



WILLIAMSPORT SUSPENSION BRIDGE
1865.
Schlesley and Montgomery *Contractors*
Scale 16' to 1" *Alfred*



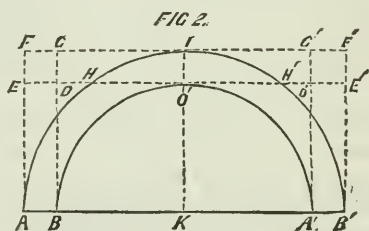
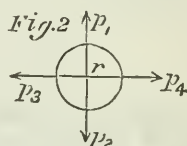
diametrically opposite *equal*. Such an absurd conclusion as the above is not yet established by mechanics.

But, without following the writer further, we now proceed to prove that there can be no tendency in the tube with *invariable circular cross-section* to straighten under an increased pressure; and thus to refute his conclusion in reference to the influence of the excess of outer circumference upon the tendency in the tube to straighten. If an elementary ring (a cross-section) of the tube be considered, as the ring r , Fig. 2, it is evident that, having the circular form, it is in perfect equilibrium in reference to an uniform pressure exerted centrifugally or centripetally upon its inner or outer surface; and therefore any two elementary forces which are diametrically opposite, as p_1 and p_2 , must be *equal*. This being so, the force acting at a , Fig. 1, equilibrates the force acting at b ; and hence the *resultant* force is *zero*, and no motion of any kind can ensue.

Thus, taking as the centre the point c , we see that the equal and opposite forces p_1 and p_2 have a common arm cd , leaving no unbalanced force or moment to cause motion around it.

In his second figure, while considering the meridian arcs AIB' and $A'O'B$, the writer loses sight entirely of all *intermediate* arcs of metal. Thus, Fig. 2, he asserts that there is nothing (save the resistance to deflection as a beam, of course,) to prevent the arcs HI and $H'I$ from spreading apart and thus causing the tube to straighten, forgetting that every point of the arc HI is connected with every point of the arc $H'I$ in precisely the same manner as every point of the arc AH is connected with every point of the arc BO' , by a ring of metal—as from H to H' , and this metal is not supposed to stretch between any of these points.

There is no tendency in the ring of metal connecting any two corresponding points of the arcs HI and $H'I$ to elongate, thus allowing these points to *separate*. On the contrary, if any such ring be considered independent (as he supposes each filament to be, wrongly, of course,) and free, then the *horizontal* pressure on its interior must give it a tendency to *draw together* these points; for being *elliptical* the pressure would cause it to assume the circular form. Hence, the influence of the excess of outer circumference HIH' would cause the tube to *coil up*, and not to straighten. He also proves (?) that all points below the line HH' are in equilibrium in respect to *two* rectangular directions; hence they are in equilibrium in respect to any direction, but by taking the point I in any other position, we may also thus prove, that some of these points are *not* in equilibrium. Why the particular arc HIH' should thus suffer does not appear.



But, again :* With the same *invariable circular cross-section the capacity of the tube cannot be increased by bending the tube ; for the present normal capacity is its maximum.* The capacity of the tube is found by the centro-baric theorem, by multiplying the *central arc*,

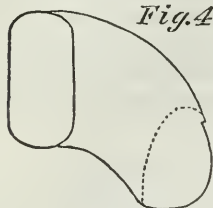


Fig. 4

Fig. 1, by the area of the cross-section, and in no form could we place this metal, preserving its circular section invariable as well as its surface, so as to increase its capacity. In fact, by bending the tube the capacity must be diminished, since the *circular section* will be destroyed. Now, the steam will force itself into the greatest possible space, thus preventing any change of shape in the tube tending to diminish its volume. Thus we prove that the tube of *invariable circular cross-section* will not tend to straighten under an increased pressure. If, however, the circular section be enlarged by the *stretching* of the metal, then our theory shows there will be a tendency to straighten under an increased pressure.

Finally, it is shown, experimentally, that the tube of cross-section represented by Fig. 4 will tend to *coil up* under an increased pressure, and that the tube of cross-section represented in Fig. 5 will tend to *straighten* under the same circumstances, corroborating the theory advanced by me, which predicts these results.



Fig. 5

In practice we often meet with very large and very long steam pipes of copper, with circular cross-sections, having a short bend at one end or both, Fig. 6 ; but these pipes never tend to assume any such position, as is shown by the dotted lines in Fig. 6, which would be the case if the short bends had any tendency to straighten. The rigidity being small could not prevent such action if it were exerted. So the small pipes of the hydrostatic press are never straightened under enormous pressure, unless their cross-section be other than a circle.

In my paper I concluded that the tube could not move until the unbalanced and concerting forces of extension and compression are excited in the metal of the tube by a change of section. These are the forces which directly act to move the tube. The explanation given in my paper is not only the "good and sufficient reason," but I think the *only* true explanation of the action of this gauge.

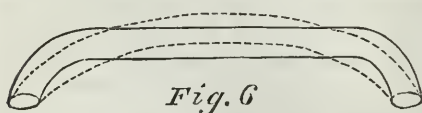


Fig. 6

P. S.—Since the above was written, a friend,—a Chief Engineer in

* In considering the effect of excess of outer circumference, the tube should be considered perfectly *flexible* and *inelastic*, and therefore liable to *wrinkle* if deflected. The tube of maximum capacity consistent with equilibrium is meant.

the Navy,—has made an experiment to illustrate the above principles. The apparatus used consisted of two rubber tubes of equal lengths, with *circular sections* curving from a common rubber bulb between them. When subjected to the hydrostatic pressure produced by filling the bulb with water, and placing weights upon it, the tubes showed no perceptible tendency to straighten; although, according to my paper, if the cross-section had enlarged by the stretching of the material, *then* a slight straightening of the tubes should have resulted. This crucial test is conclusive of the correctness of the theory I have mathematically demonstrated.

For the Journal of the Franklin Institute.

On the Steam and Exhaust Ports of Steam Cylinders—The practicability of a material reduction in their dimensions suggested. By D. M. GREENE, U. S. Naval Engineers.

The rules employed by designers of steam machinery in determining the areas of steam ports and passages, seem to be generally, if not always, entirely arbitrary; indeed, the "*rule of thumb*" appears to be not only the principal one used, but to find advocates in quarters and under circumstances where they would be least expected. The ever-varying conditions of steam pressure and velocity of piston appear to be ignored, and the unwarrantable assumption made, that the relation between the areas of the ports and passages, and of the piston once determined, for an engine working under a given steam pressure, and with a given velocity of piston, furnishes a reliable precedent in designing all engines whatever may be the conditions under which they are to perform their functions.

In engines of great power, having large cylinders, and using steam of more than ordinary high pressure, great difficulty has been experienced in securing a proper action of the valves. This has been owing to the excessive weight of the valve, together with the enormous steam pressure upon its back, causing a rapid destruction of its face by friction. Much ingenuity has been expended in providing remedies for this evil, and as the results we have, among other contrivances, the "vacuum ring," the "Wadell plate," and the steel roller, all of which possess merit; but which, while affording partial relief, are objectionable on account of the difficulty attending their proper fitting up and adjustment, and especially on account of their liability to derangement after having been once adjusted.

It seems strange that, while so much has been done to mitigate the effect of the evil of large and heavy valves, nothing appears to have been done to reduce the *evil itself* to its minimum practicable proportions. Why has not some one suggested that the ports, and consequently the valves, as now proportioned, may be twice or even three times as large as necessity requires?

The writer, in constructing a formula for his own use in determining the proper areas of opening for steam ports, has had his attention forcibly directed to this matter by the result obtained; and, feeling

that the subject is one of profound interest to the profession, will now indicate the course pursued by him in its examination.

Steam passes from the steam chest to the cylinder by virtue of an excess of pressure in the former over that in the latter. What this excess of pressure is, however, in practice, we are without reliable information; no experiments, to our knowledge, having been made with a view to determine it.

Indeed, such information is not essential; as we may assume any admissible excess of pressure, and base our determination upon such assumption. We will, therefore, assume 0·3 of a pound as an excess which is not only entirely admissible, but even considerably less than may be allowed in practice. This assumption being made, the velocity with which the steam will enter the cylinder through the port will be that due to the height of a column of the entering steam, the weight of which is equal to the assumed excess of pressure; in other words, the velocity of the current will be that which a body would acquire, in falling freely through the height of a column of the entering steam, having a base of one square inch, and weighing 0·2 of a pound. The volume of steam admitted through the port will depend upon the area of the port and upon the velocity of the current; while the volume of steam required to be admitted in the same time, will depend upon the area of the piston and its velocity.

In order to express these conditions in the form of an equation, let

D = diameter of cylinder in inches.

A = area of piston in inches.

v = velocity of piston in feet per second.

a = area of steam port in square inches.

$K a$ = effective steam port in square inches.

v = velocity of entering steam in feet per second.

s = stroke of piston in feet.

p = pressure of steam in steam chest above zero.

δ = difference of pressure in steam chest and cylinder.

h = height due to v .

c = specific volume of steam of pressure p .

r = number of revolutions per minute.

Then will

$$v = \sqrt{2gh},$$

and

$$K a v = K a \sqrt{2gh};$$

which represents the volume of steam admitted to the cylinder per second. But this volume is also represented by $A v$; hence

$$K a \sqrt{2gh} = A v;$$

whence

$$a = \frac{A v}{K \sqrt{2gh}}, \quad . \quad . \quad . \quad (1.)$$

Now, $A = .7854 D^2$, and $v = \frac{2 r s}{60} = \frac{r s}{30}$.

Substituting in (1) we get

$$a = \frac{.7854 D^2 r s}{30 K \sqrt{2 g h}}, \quad (2.)$$

To determine h , in terms of c and δ , we have but to remember that a column of steam of the pressure p , having a base of one square foot, and a height of c feet, weighs 62.5 pounds; while if the base be but one square inch, the weight of the column will be $\frac{62.5}{144}$ pounds; then to find how much of this column will be required to weigh δ pounds, we have the proportion,

$$\frac{62.5}{144} : \delta :: c : h;$$

whence

$$h = \frac{144 \delta c}{62.5} \\ = 2.304 \delta c.$$

Substituting now this last value of h in (2) we get

$$a = \frac{.7854 D^2 r s}{30 K \sqrt{2 g \times 2.304 \delta c}} \\ = \frac{.7854}{30 \sqrt{2} \times 32.16 \times 2.304} \times \frac{D^2 r s}{K \sqrt{\delta c}} \\ = \frac{.7854}{30 \times 12.17} \times \frac{D^2 r s}{K \sqrt{\delta c}} = .00216 \frac{D^2 r s}{K \sqrt{\delta c}}, \quad (3.)$$

If we make $\delta = 0.3$ of a pound, as already indicated, (3) becomes

$$a = \frac{.00216}{\sqrt{0.3}} \times \frac{D^2 r s}{K \sqrt{c}} = .004 \frac{D^2 r s}{K \sqrt{c}}, \quad (4.)$$

For long and narrow rectangular ports, K may be taken as .8, and (4) will become

$$a = .005 \frac{D^2 r s}{\sqrt{c}}, \quad (5.)$$

For circular ports, as when the puppet valve is employed, K may be taken as .62, in which case (4) becomes

$$a = .00645 \frac{D^2 r s}{\sqrt{c}}, \quad (6.)$$

The following table furnishes a few values of c . Where the values of p differ from those given, recourse may be had to a more complete

table; or, in its absence, c may be determined with sufficient accuracy by the "Law of Mariotte."

p (In pounds above zero).	c	p (In pounds above zero).	c
15	1669	105	282
30	883	120	251
45	610	135	224
60	470	150	205
75	383	165	187
90	325	180	174

To exemplify the application of our results, let $D = 100''$, $r = 40$, $s = 4'$, and $p = 60$ pounds. Then will (5)

$$a = .005 \times \frac{100^2 \times 40 \times 4}{\sqrt{470}} = 368.75 \text{ square inches.}$$

Thus we see that, the ports being rectangular, the aggregate opening at each end of the cylinder should be 368.75 square inches. If the ports be double, and their lengths be 82 inches, their widths will evidently be $\frac{368.75}{2 \times 82} = 2.25$ inches.

Again, let $D = 60''$, $r = 65$, $s = 2\frac{1}{8}'$, and $p = 45$. Then will (5)

$$a = .005 \times \frac{60^2 \times 65 \times 2\frac{1}{8}}{\sqrt{610}} = 102.6 \text{ square inches.}$$

The data for these examples are taken from the "one hundred inch" and the "sixty inch" engines, now being constructed for the Navy Department; and the results are practically identical with the areas given to the ports of the cylinders of those engines. These areas were determined by the usual method, *i. e.* by making them a certain function of the areas of the pistons; whereas, it is apparent, from the formula, as well as suggested by common sense, that they should also have been made functions of the number of revolutions and the strokes of the pistons.

To prevent any misapprehension in regard to the apparent coincidence of the results given by the two methods, it is proper to remark that, had the number of revolutions proposed in the first example been 50, instead of 40, the resulting area of the port given by the formula would have been 25 per cent. greater; while the result given by the "rule of thumb" would have been the same.

It may be said that a larger cylinder would have been required, but even then the increased speed of piston would have rendered the result unreliable.

Now, to ascertain whether or not it be practicable to reduce the areas of these ports, let us solve (3) with respect to δ . We get

$$\delta = \frac{.00216^2 D^4 r^2 s^2}{a^2 K^2 C};$$

whence it appears that, other things being equal,

$$\delta \propto \frac{1}{a^2}.$$

Let now a_1 and δ_1 represent another area of port, and the corresponding value of δ , respectively; then we have from the relation just noticed,

$$\delta : \delta_1 :: \frac{1}{a^2} : \frac{1}{a_1^2};$$

whence

$$\delta_1 = \delta \cdot \frac{a^2}{a_1^2}.$$

If $a_1 = \frac{1}{2} a$, this becomes

$$\delta_1 = \delta \cdot \frac{a^2}{\frac{1}{4}a^2} = 4 \delta;$$

but we have constructed our formula, and applied it upon the hypothesis that $\delta = 0.3$;

$$\therefore \delta_1 = 4 \times 0.3 = 1.2 \text{ pounds.}$$

Thus it appears that, in order to realize the advantages of a port only one-half as large as that now employed, we have only to increase the boiler pressure 0.9 of a pound. If a_1 had been made $= \frac{1}{3}a$, we should have found

$$\delta_1 = 9 \delta = 9 \times 0.3 = 2.7 \text{ pounds,}$$

which shows that, as the area of the port is made considerably less than one-half that which is at present employed, the excess of pressure in the steam chest over that in the cylinder soon becomes too large to be admissible.

Among the important advantages which would result from the adoption of a port one-half the present size would be: first, a saving of nearly or quite one-half in the weight of the valve, and in the steam pressure in its back; and second, a very large saving in the clearance space in the nozzles.

To best secure these advantages, the present *width* of port should be preserved, while the *length* should be reduced one-half. (5) and (6) for this case would become

$$a = .0025 \cdot \frac{D^2 r s}{\sqrt{c}} \quad . \quad . \quad . \quad (5a,)$$

for rectangular ports, and

$$a = .0032 \cdot \frac{D^2 r s}{\sqrt{c}} \quad . \quad . \quad . \quad (6a,)$$

for circular ports.

In this connexion, it may not be amiss to call attention to the (to

our mind) absurd practice of making the exhaust openings and passages twice as large as the steam passages. It will be remembered that, in the first example given, the velocity with which the steam enters the cylinder is due to an excess of pressure in the steam chest of only 0.3 of a pound; while the absolute pressure, at the end of the stroke, which forces the exhaust into the condenser is—allowing for the reduced pressure due to expansion—about 51 pounds. Now, $\frac{51}{0.3} =$

170; or the pressure head to which the velocity of discharge is due is about 170 times as great as that to which the velocity of the steam entering the cylinder is due; and since these velocities are proportional to the square roots of their respective pressure heads, they will be to each other as $1 : \sqrt{170}$; or, $1 : 13$. Hence, in this particular case, the velocity of egress will be 13 times as great as the velocity of ingress. With the more usual pressures of 30 to 40 pounds above zero, the velocity of egress will be about 10 times that of ingress. Even with the reduced port, in the case of the “hundred inch” cylinder, the velocities would be $1 : \sqrt{1} : \sqrt{\frac{60}{1.2}}$; or, $1 : 7$.

Why, then, make the exhaust opening larger than the steam opening?

The suggestions contained in this paper are offered especially for the benefit of the younger members of the profession; and also in the hope that individuals having facilities may be induced, by the importance of the subject, to institute experiments with the view of ascertaining whether the advantages claimed for the reduced port may or may not be realized.

Washington, D. C., February 15, 1866.

Phillips' Patent Girder and Fire-proof Flooring.

From the London Mechanics' Magazine, December, 1865.

On Tuesday last some important experiments took place at Mr. Kirkaldy's testing works, the Grove, Southwark, with the above inventions, in the presence of a large number of practical engineers and other scientific gentlemen. Mr. Kirkaldy, who has long been known in connexion with experiments on iron and steel, has recently erected an enormous machine, possessing testing powers from ten pounds to one million pounds, which records its own progress and conclusions with the certainty and exactitude of a chronometer. He conducted the experiments in person, assisted by Mr. Homan. The patentees of the girder, Messrs. W. and T. Phillips, of the Coal Exchange, were also present. The peculiarity of the new invention consists in the flanges being rolled solid, instead of being riveted as heretofore, whilst the web is somewhat thicker than usual. The first experiment was with a light girder 8 inches deep, with $2\frac{1}{2}$ inches flanges, and 20 feet between the supports; the weight was 22 pounds per foot run, the iron being equal to ordinary Staffordshire plate. For the purpose of

understanding the comparison it may be stated that the breaking weight of a similarly sized riveted girder is about four tons, the distributed safe load being about two tons. In the experiment with the new girder the old breaking pressure of four tons was immediately applied; when withdrawn after a short time it was found that the limit of electricity had not been reached, as no permanent set was discernible. Five tons were then put to the centre of the beam, as before, which showed a permanent set in the metal, but to the smallest appreciable extent. The pressure was then increased for breakage, and at about seven tons the supports gave way, and the beam turned over from the machine. Examination was critically made to discover fracture, but, although a considerable vertical set had taken place, no separation of the metal was observable. The next experiment was a girder having the lower flange $2\frac{1}{2}$ inches by $\frac{3}{8}$ inch, the top flange being 8 inches by $\frac{3}{8}$ inch, whilst the depth was about 16 inches; this girder was riveted in the middle. The breaking weight of a similar girder with riveted flanges is ten tons, but the new solid rolled flange refused to move under that pressure, or even at twelve tons. The strain went on to sixteen tons, when it began to set only, and at eighteen tons it jumped out of the machine like the previous ones, through the giving way of the supports. A close inspection showed that beyond the slight setting this girder has suffered no injury whatever; and, as it so far exceeded Mr. Kirkaldy's expectations of its resisting powers, it was agreed to postpone the remaining experiments for a month, in order that the testing machine should be expressly prepared for this unlooked-for new girder.

Advantage was then taken of the opportunity to inspect the Messrs. Phillips' new fire-proof flooring. It consists of rolled iron joists 2 feet apart, with iron laths resting on the bottom flange. On these laths concrete is laid to the depth of four or five inches, and in the concrete the dove-tailed timber joists are buried. The under side forms an effectual key for the plaster ceiling, which can be easily applied by any ordinary workman. It is believed that this floor can be laid as cheaply as any ordinary floor, and at much less cost than any fire-proof flooring now used.

For the Journal of the Franklin Institute.

"Vacuum" and the Indicator. By JOHN T. HAWKINS, First Asst. Eng. U. S. Navy.

I have on many occasions observed that there exists, and among young engineers particularly, a very material confusion of ideas upon the real condition of things within the condenser of a steam engine. Nor is it to be wondered at that this is the case under the present system of expressing the variations of pressure within a condenser in "inches of vacuum," the numbers increasing as the pressure diminishes seeming to them to represent, not the pressure therein, as it should, but certain degrees of absence of pressure,

A perfect vacuum, or total absence of pressure, is an unvarying standard, and to simplify the real relations of the condenser with the boiler, instruments now known as vacuum gauges should be changed in name and made to record upward in pounds per square inch, precisely as the steam gauge does; then the apparent mystery surrounding the idea of a vacuum would never insinuate itself into the minds of learners nor cause confusion among the better informed.

All vacuum gauges of the nature of the closed top manometer, as the scale upon them is now arranged, indicate incorrectly for every variation of the atmospheric pressure and can only be correct for one. For instance, the manometer scale is graduated upon the supposition that the atmospheric pressure is equal to 30 inches of mercury, and the lowest figure upon the scale is 30, diminishing upward. If, with a perfect vacuum in the condenser, the mercury descends to the point marked 30 at one pressure of the atmosphere it will at any other, or even if there were no atmospheric pressure at all; so it is manifestly incorrect to say that the vacuum in the condenser is equal to 30 inches of mercury, if the pressure of the atmosphere will support no more than 28 inches, or if it be sufficient to support 31 inches. But if we place 0 upon the scale in the place of this 30, and graduate it upward in divisions representing pounds and fractions of pounds pressure to the square inch in the condenser, this gauge will indicate absolutely correct whatever the variation may be of the atmospheric pressure; and, moreover, it would be impossible to misapprehend the indications.

With all vacuum gauges that are affected in their indications directly by the variations of the atmospheric pressure, such as the open syphon and the different varieties of spring gauge, we must make corrections, by means of the barometer, to be able to determine the exact pressure in a condenser; and it would be just as easy to do this if the numbers began at the perfect vacuum point and read upward as the pressure increased, as it is now with the numbers reading in the other direction, and would be much more intelligible. There can be no positive point upon the dial or scale of such a gauge to indicate a perfect vacuum, nor can there be any such point at which any given pressure in the condenser can be recorded, no matter in what particular manner the dial or scale may be divided or numbered, so that the corrections must be made for every variation of the atmospheric pressure under any circumstances; and certainly it would be much less ambiguous to have the indications read, for instance, 2 lbs. pressure in the condenser—and be sure to convey that idea to the mind—instead of 26 ins. of vacuum; for to know the pressure (which is what we really require) we must deduct this 26 from 30, and if the barometer reads 28 ins. instead of 30 ins. we must deduct 24, which the gauge would then indicate, not from 30 but from 28, while, under the same conditions, (the scale counting upward in pounds,) the scale would indicate 3 lbs. pressure, and we would have to simply reduce that indication one-half pound for every inch the barometer stood below 30.

We may trace the results of this really erroneous method of indicating pressures below that of the atmosphere to that very important

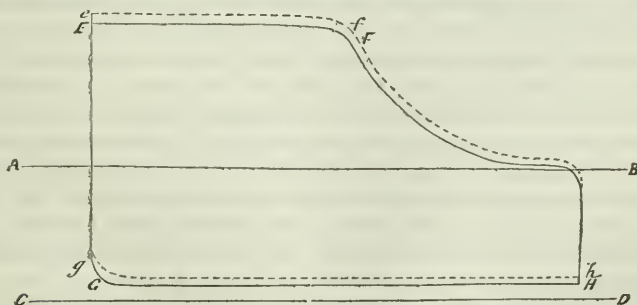
instrument, the indicator, and find that it gives rise to errors of a considerable magnitude where accuracy is required.

The indicator itself is nothing more than a pressure gauge, indicating, precisely as the open mercurial or the various spring gauges do, the difference of the atmospheric pressure and that within whatever vessel it may be attached to, varying in those indications with every variation of the pressure of the atmosphere.

It is customary, and indeed very explicit instructions are given to engineers, to take both the atmospheric and perfect vacuum lines upon a diagram; but how to take them, or rather, make them correct, is not always told, and in many cases is not really understood. Most indicators are arranged with a stop, down to which the piston may be forced, and a line traced by the pencil while so held by the hand is generally regarded as the perfect vacuum line, to which all other lines in the diagram may be referred. Now, it would appear to many at first sight that, inasmuch as the atmospheric pressure varies while a perfect vacuum does not, if a correction is necessary to be made for a variation in the atmospheric pressure, it only requires that the atmospheric line, as traced by the instrument, shall be raised or lowered accordingly as the atmospheric pressure is greater or less than 30 ins. of mercury.

It is not difficult, however, to show that the only line to which all parts of an indicator diagram may be referred, truly, is the atmospheric line taken with the pressure of the atmosphere admitted to both sides of the indicator piston, for which provision should always be made in the arrangement of an indicator or the pipes and cocks connecting it with the cylinder.

To make the truth of this statement quite clear, suppose the continuous line EFHG in the figure to represent a diagram taken from a condensing engine; AB the atmospheric line taken with the atmo-



sphere admitted to both sides of the indicator piston; CD the perfect vacuum line, taken by forcing the piston down to the stop. Let the scale of the indicator be 1 inch = 10 lbs., the atmospheric pressure = 14.7 lbs., and the total initial pressure in the cylinder = 29.7 lbs. Under these circumstances, the vertical distance between the perfect vacuum and atmospheric lines will = 1.47 inches, and that between the atmospheric line AB and the steam line EF will = 1.5 inches;

and if there be, say, 2 lbs. pressure to the square inch in the condenser, the distance between the vacuum line $g h$, traced by the instrument and the perfect vacuum line will $= 0.2$ inch.

Now, to prove that this perfect vacuum line is not correct for any other pressure of the atmosphere, let us see what the effect will be, upon the entire diagram, of a reduction of the atmospheric pressure to 13.7 lbs. First, the vacuum line traced by the instrument, instead of being found at $g h$, will be 0.1 inch higher, as the dotted line $g h$, because with a given pressure beneath the indicator piston the reduced pressure of the atmosphere is insufficient to depress it so far. Again, we will find the steam line, instead of $E F$, will be traced 0.1 inch higher also, as $e f$, because a given pressure beneath the indicator piston is sufficient to force it higher with the pressure above it diminished. The whole diagram, therefore, will be traced 0.1 inch higher, relatively to either the atmospheric line $A B$, or the perfect vacuum line $C D$.

But with the pressure of the atmosphere at 13.7 lbs., the vertical distance between the atmospheric and perfect vacuum lines should be but 1.37 inches; one of these lines is, therefore, incorrect; either $A B$ is too high, or $C D$ is too low. Let us see which it is.

If the line $C D$ correctly represents the perfect vacuum, the vertical distance between it and the dotted steam line $e f$ should be 2.97 inches, for that distance represents the total pressure, which has not been altered; and for the same reason the vertical distance between $C D$ and the dotted vacuum line $g h$ should be 0.2 inch. But we see that those distances will be respectively equal to 3.07 and 0.3 inches. It is clear, then, that the line $C D$ does not correctly represent the perfect vacuum with the atmospheric pressure at 13.7 lbs.

Now, if we refer either the dotted or full line diagram to the atmospheric line $A B$, we find it correct for both; for the vertical distance between it and the vacuum line described by the instrument varies exactly with the pressure of the atmosphere, as it should; and the same is the case with the steam, or any other line above it; thus the distance between $A B$ and $e f$ will be 1.6 inches, as it should, and that between $A B$ and $g h$ will be 1.17 inches, which is equally correct.

If it were required to calculate the weight of steam used per stroke from the diagram $g e f h$, and the line $C D$ be taken to represent the perfect vacuum, as is quite often done, it is plain that a very considerable error would be the result; for the diagram exhibits, under these conditions, a greater pressure by 1 lb. than actually existed in the cylinder, and at every part of it.

The true method, then, of taking an indicator diagram is to admit the pressure of the atmosphere to both sides of the indicator piston when the atmospheric line is traced, record the reading of the barometer after the entire diagram is taken, and lay off the perfect vacuum line from the atmospheric one at our leisure, and in accordance with the barometric record.

It might be urged, that having the record of the barometer at the time the diagram was taken, we can lay off the perfect vacuum line

as well from the false one, taken by depressing the indicator piston to the stop provided for the purpose, as from the atmospheric line. And so we may; but the atmospheric line does not belie its name, and no confusion of terms or ideas can result from referring the entire diagram to it, while with the false vacuum line such a result is more than probable; indeed, I have seen this exemplified on many occasions; beside, one line is sufficient, and, that being the case, we do well to take that which is always correct.

The term "vacuum," as applied to the condenser of a steam engine, is at best a grievous misnomer, and the term "partial vacuum," together with the idea it conveys, is no less than absurd. Either there is a vacuum or a pressure, and the latter invariably obtains in the condenser. No matter how great or how small that pressure may be, it is never in any correct sense a partial vacuum. As well might we say of a boiler having a pressure within it of 100 lbs. to the square inch, when referring it to, or comparing it with, another in which 101 lbs. was maintained, that there was a partial vacuum within it, as to say there is a partial vacuum in a condenser because the pressure therein was something less than that of the atmosphere outside. Or, if the barometer indicates to-day 23 inches and to-morrow 30, it could with equal propriety be said that to-day we have a partial vacuum around us.

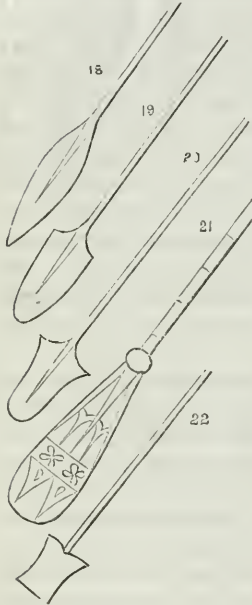
So long as the atmospheric pressure varies, there can be no positive line drawn to divide what, under the present system, is understood as a partial vacuum from a positive pressure; and herein lies the evil. The use of the term "vacuum" should only be to express a total absence of pressure, and any deviation from that condition should be regarded as something positive and capable of being measured. A vacuum can no more be measured than can a mathematical point, and it should be presented to the minds of learners in just that sense; then they would not be obliged to unlearn in their maturer years the erroneous impressions received by them during their younger days, as is certainly now the case to a great extent, so far as this subject is concerned.

I have seen so many instances of the bad effect of the misuse of these terms, authorized, and indeed rendered almost indispensable, under the present system of dividing and numbering the figures upon the dials or scales of instruments for measuring condenser pressures, that I am persuaded a radical change should be made, and that the sooner it is commenced the better. The form in which this subject is now generally presented to our view is but a relic of by-gone times, when men's minds had not yet been entirely freed from the gloom of the dark ages; when nature was supposed to possess many mysterious and unfathomable secrets, since revealed by the steadily increasing brightness of the head-light of science, as the iron horse of investigation came thundering down the track of time.

For the Journal of the Franklin Institute.

Increasing the Speed of Steamers—Form of Propelling Blades—The Oar and Paddle.

Since forwarding the article in last month's *Journal*, I have selected from the volumes of Champollion and Rosellini the annexed illustrations. In tome iv. of the former, Plate 403, are two Egyptian galleys with oars acutely tapered and pointed as in Fig. 18. This was a common form. (See tome ii., Plates 127, 128, 130.) *Oar makers* are represented at work dressing the shafts of blades, all spear-shaped, tome iv., Plate 369, and Rosellini, tome ii., Plate 43. The central longitudinal ridge is marked on all.



19 and 20. Oars in the hands of boatmen about to step on shore, Ros. tome ii., Plate 105. The blade of the latter is identical with that of the Indian paddle, in the *Journal of the Franklin Institute*, for October, 1848.

21. Specimen of ornamented rudder-oars—the common form; some are less, others more elaborately decorated by carving and painting.

22. An Assyrian oar from a Brieme in the palace of Sennacherib. Rawlinson's *Herodotus* i., 232: London, 1862. In Olaus Magnus' *History of the Goths—Historia Olai Magni Gothi Archiepiscopi Upsalensis de Gentium Septentrionalium*, . . . Basil, 1567, —the oar repeatedly occurs in the numerous wood-cuts and, except acutely pointed blades, in most of the forms already given.

The fact that in nature increased speed is not accompanied with enlarged propelling surface should have been dwelt on. The mechanical principle is not only of special interest in itself, but of the very first importance in naval engineering. Its practical value cannot be over-estimated, yet it does not appear to have been thought of, and but for its demonstration in natural organisms would not now be believed in, so contrary it is to our general practice. The more sail a ship carries the faster she moves, and to double the speed of a bird the common inference would be that its wings should be enlarged. Had this been the law some departments of creation would present very different scenes to those we behold. To convert slow into swift flyers and swimmers, propelling organs would have been three or four times heavier than now and required corresponding additions of force to work them. Such is the plan we have followed instead of the living one before us, which, to say the least, should be tried, since it is granted on all hands, that increased speed must be obtained and will be, if not by us, by those who come after us. Some leading authori-

ties for the enunciation and elucidation of new doctrines in natural, and, consequently, in practical mechanics are greatly needed.

Undeveloped agents are wanted for some arts to advance, but for propulsion we appear to possess all that engineers for ages will have as regards materials and forces, so that there is nothing to prevent us from anticipating them in high speeds if we will but make the best use of the means in our power.

E.

Large Iron Railway Bridge.

From the London Mechanics' Magazine, December, 1865.

The Newhaven, Hartford, and Springfield Railroad Company are now erecting a fine bridge across the Connecticut River at Warehouse Point. When completed this will probably be the finest railroad bridge in the United States. It is built on the truss principle, and consists of seventeen spans, the longest being 177 feet, extending over the river, the carriage road, canal, and tow-path. The entire length of the structure is 1525 feet. The total weight of iron used in its construction is about 700 tons, and cost in England, where it was made, £11,231. The plans for its construction were designed by Mr. James Laurie, an American engineer, and were at first tendered to an iron firm in Philadelphia, but at that time nearly all the large iron workers in the country were engaged on government work, and it was finally determined to procure the construction of the bridge in England. The contract was awarded to William Fairbairn & Co., of Manchester, but afterwards a portion of it was assigned to the London Engineering and Ship-building Company. The bridge being built in sections and fitted together, was then taken apart and shipped to America. About 175,000 rivets are employed in fastening together the various pieces. The great difficulty encountered in putting the bridge in its place arose from the fact that the new bridge is to occupy the same position as the present wooden one, and it was desirable that the traffic of the road should not be interrupted while substituting the one for the other. A good deal of planning and study was required to effect this object, but the skill and ingenuity of Mr. Laurie have hitherto overcome all obstacles, and most of the spans are now in position, without, we believe, a single interruption to any train. The erection of the bridge was commenced about the 1st of July last, and it is expected that the entire structure will be in position and completed by the end of January next.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Expansion Trials with the U. S. Steamers Algonquin and Winooski.

By ISAAC NEWTON, late of the Engineer Corps, U. S. N.

A number of indicator diagrams, taken from various steamers fitted with precisely the same valves and valve gear as that of the *Wi-*

nooski, and an examination of the cut-off of a number of the same type of engine to which an indicator has not been applied, exhibited the fact that the usual point of cut-off adopted in American marine practice is from *four* to *five*-tenths of the stroke of the piston. It may therefore be assumed that this measure of expansion, taking the usual conditions of practice into consideration, is the measure which has been found to give the best practical results. This does not prove, however, that no gain can be attained by suppressing the admission of the steam at an earlier point of the stroke; on the contrary, many well attested examples prove that a gain has been effected by shortening the cut-off. In the Cornish pumping, which is well known as one of the most economical types of steam engine, the steam is frequently cut off at from one-twelfth to one-sixth of the stroke; the performances of well-proportioned engines of this class, in good order, are too well known to require repetition here. Not only in the Cornish engine, but also in reciprocating engines, has an equal increased efficiency been the result of an extensive application of the expansive principle.

Toward the close of the year 1860, Mr. Isherwood, the present Chief of the Bureau of Steam Engineering of the Navy Department, carried on a series of expansion experiments on the U. S. paddle steamer *Michigan*, on Lake Erie. Hence the name by which these experiments have since been known, "Erie Expansion Experiments." The results of these experiments, as "discussed" by Mr. Isherwood, are of such a remarkable character, and as his subsequent practice as Engineer in Chief has been governed entirely by his opinion of these results, the profession have watched the so called economy dock trials between the *Algonquin* and *Winooski* with more than ordinary interest. It is true these trials were ostensibly started in order to prove whether or no certain stipulations in a contract had been fulfilled, but the only valuable or interesting point involved—for reasons already mentioned—was the value of the theories maintained by the Chief of the Naval Steam Bureau, with respect to the expansive principle. To make a long story short, the position taken by this gentleman was, that this principle was a delusion. In order that these experiments may be fully comprehended, the principal features and dimensions of the competing machinery will be given.

First. The *Algonquin*, the entire machinery of which vessel was designed by Mr. E. N. Dickerson, a lawyer by profession, but one who has devoted much attention to steam engineering. This vessel is fitted with an ordinary inclined engine, the cylinder of which is 48 inches in diameter by 10 feet length of stroke; the valves are of the single poppet style; the steam valves are arranged with the old "drop valve cut-off," which is easily adjustable, while the engine is in motion, to any point of the stroke.

The clearance at each end of the cylinder between the piston and valves is 7.5 cubic feet.

The steam is condensed by a surface condenser of very great external magnitude in proportion to the refrigerating surface exposed to the steam and condensing water.

The refrigerating water from the sea is forced through this condenser, by means of a small centrifugal pump, driven by an independent oscillating engine devoted solely to that duty.

The boilers are of peculiar construction, patented by Mr. Dickerson, and are braced for an excessive working pressure. The chief heating surface consists of a great number of inclined water tubes, placed as it were within the furnace itself. The boilers are also provided with a considerable area of superheating surface, which consists of a number of vertical tubes, through which the products of combustion pass on their way to the chimney; the lower end of these tubes enter the crown-sheet of the furnace, and are, of course, surrounded by water. The feed-water is heated by means of casing surrounding the base of the smoke pipe.

The principal dimensions of the boilers are as follows:

Total grate surface, ...	* 144 square feet.
Total heating surface, ...	2678 " "
Total superheating surface in the superheating tubes, ...	1132 " "

The average pressure carried during the late trials at the wharf was about 70 lbs. per square inch, and the point of cut-off about *one-tenth* of the length of the stroke. Thus, the well read engineer will see, that in this machinery the attempt was made to carry out the most economical modern practice; all the elements of the best practice of the best known English engineering firms were embodied in this engine, the point of cut-off and the pressure of the steam being carried to extremes.

The engine of the *Winooski* is also the ordinary inclined engine—such as may be seen at most of our ferry boats. The valves are of the usual American equilibrium variety. These valves, and the mechanism which works them, are such as are universally used in paddle wheel steamers in this country, and the valves and valve gear, taken as a whole, is looked upon as one of the best examples of American engineering skill; the result, in fact, of years of experience. The independent cut-off gear is known as the “Stevens,” and can only be adjusted (in ordinary practice) by going through quite a lengthy process of changing, pins, eccentrics, and wipers. The principal dimensions of this engine are as follows:

Diameter of cylinder, ...	4 feet 10 inches.
Length of stroke, ...	8 “ 9 “
Diameter of piston rod, ...	6½ “
Volume swept by piston at each stroke, exclusive of the rod, ...	159.53 cubic feet.
Clearance at one end of the cylinder, including steam passage, &c., ...	13.52 cubic feet.
Diameter of the double beat steam valves	15½ and 16½ inches.
Diameter of the double beat exhaust valves, ...	15½ and 16½ “
Diameter of the openings into and out of the cylinder, ...	393 square inches.
Diameter of air pump, ...	2 feet 7 inches.
Diameter of circulating pump, ...	2 “ 7 “
Stroke of circulating pump, ...	4 “ 4 “

One barrel used for both pumps.

Area of refrigerating surface on the tubes of the surface condenser, ...	2293 square feet.
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* This was reduced, during a great portion of the trial, by bricking up the back ends of the grate bar to about 130 square feet.

In short, this engine is a good copy of the ordinary American poppet valve expansion engine, such as is universally used in this country.

The steam is condensed by a surface condenser, the refrigerating water being driven through it by means of a reciprocating pump, driven by the main engine.

The boilers are of the vertical tubular type, such as are universally used in the naval service. The principal dimensions are as follows:

Heating surface in both boilers in 10 furnaces,	375.13 square feet.
Heating surface in both boilers in 10 combustion chambers,	105 " "
Heating surface in both boilers in 10 back connexions,	326.32 " "
Heating surface in both boilers in 10 tube boxes,	647.71 " "
Heating surface in tubes of both boilers,	3453.96 " "
Heating surface in uptakes 9 inches above tubes,	127.88 " "
Total heating surface in both boilers,	5036 " "
Superheating surface in uptakes of both boilers,	171 " "
Grate surface in both boilers,	200 " "
Cross area of smoke pipe,	23.7 " "
Cross area through tubes for draught,	26.6 " "

The paddle-wheels of both vessels are precisely the same, having been built from the same drawings; they are of iron, 26 feet in diameter, with 24 wooden paddles, 9 feet long by 15 inches in width.

During the late trials they were fitted with paddles of the same dimensions and immersion in the water. The condition of the wheels during the late trials was as follows: Diameter over the paddle, 22 feet 6 inches, each paddle 9 feet in length by 7 inches in width; number in each wheel 24; maximum immersion of the lower edge of the paddles $27\frac{1}{2}$ inches.

The useful power developed was therefore measured by the number of revolutions made by the wheels in a given time, and the cost of that power by the quantity of fuel consumed in the furnaces of the boilers. This is a very simple method, as it avoids much calculation. But it should be mentioned, that in order that this method of measuring the relative power of two engines—one working with a very high measure of expansion, and, of course, having a very *ununiform* pressure on the piston, and consequently on the paddles; the other working with an ordinary measure of expansion, and consequently with a much more *uniform* pressure on the piston and the paddles—that the paddles should be so proportioned that the velocity through the water should be uniform. For if this is not the case, as the power required to force the paddles through the water varies as the *cube* of the speed, it will be readily perceived, that if one wheel moves irregularly and the other uniformly, the revolutions of the wheels cannot be an accurate dynamometric test of the relative powers developed. Now, as the wheels of the *Algonquin*, on the dock trials, actually did revolve irregularly, while those of the *Winooski* revolved practically uniformly—owing to the more uniform pressure on her piston—it will be seen that this measure of the power gave less than the true result for the *Algonquin*, in proportion to the more irregular motion of her paddles.*

* The *Algonquin* halted on each centre, while the cranks of the *Winooski* revolved, as far as the eye could detect, with a uniform velocity. At the commencement of the trials, Mr. Isherwood desired to so arrange the paddle surface, that the *Winooski*, burning 1600 lbs. of coal per hour, would make but $13\frac{1}{2}$ revolutions.

The first economy trial between these vessels commenced on Friday afternoon, September 22, 1865.

The *Algonquin* started her engine at 4.47 P. M., and it was kept in continual operation until 11 P. M., Sunday, when her feed-pipe was fractured, and it was necessary to stop the engine.

The engine of the *Winooski* was started at 5.11 P. M. of the same day, and completed the stipulated time of 96 hours, or 4 days.

The conditions of the trial were, that each vessel should burn not exceeding 1600 lbs. per hour, and that the trial should last 96 hours. Both vessels were lashed to the wharf, and the power, as before mentioned, was measured by the revolutions of the wheels.

The following is the data of this trial, extracted from the report of the Naval Engineers to the Secretary of the Navy:

	Winooski.	Algonquin.
Total time of trial in hours, ...	51	51
Total number of revolutions of wheels, ...	45,149	44,918
Total number of pounds of anthracite, ...	80,400	79,239
Average number of revolutions per minute, ...	14.7564	14.6791
Average number of pounds of coal per hour, ...	1,576.5	1,553.7
Average pressure of steam in boiler, ...	16.8	70.79
Average point of cutting off, ...	0.47†	0.11
Vacuum in condenser in inches of mercury, ...	27.65	22
Back pressure in cylinder in lbs. per square inch, by indicator, ...	1.50	4.00
Mean indicated pressure on piston, in pounds per square inch, ...	24.87	31.06
Indicated horse power, ...	520.17	500.01
Pounds of coal per hour per indicated horse power, ...	3.031	3.107
Temperature of feed-water, ...	112°	158°

Data of the Second Economy Trial, extracted from the report of the Board:

	Winooski.	Algonquin.
Date of commencement, October 23, 1865, P. M., ...	4.23	4.22
Duration of experiment in hours and minutes, ...	96	69.8
Total number of revolutions, ...	85,884	62,407
Total number of pounds of coal consumed, ...	152,015	111,344
Total number of pounds of refuse from coal, ...	30,400	19,500
Total number of pounds of coal consumed, less refuse, ...	121,615	91,844
Per centum of refuse, ...	20	17.51
Average pressure in steam pipe in pounds per square inch, ...	19.64	71.63
Average point of cutting off the steam, ...	0.619*	0.132
Average vacuum in condenser, in inches of mercury, ...	27.80	20.54
Average barometer, (Aneroid,)	29.94	29.94
Average revolutions per minute, ...	14.9104	15.0450
Average indicated pressure on piston, ...	26.276	31.6
Average indicated horse power, ...	545.48	517.31
Pounds of coal consumed per hour, ...	1,583.4	1,610.5
Pounds of coal consumed per hour, less refuse, ...	1,266.8	1,348.50
Pounds of coal per hour per indicated horse power, ...	2.905	3.113
Pounds of coal per hour per indicated horse power, less refuse, ...	2.322	2.568
Temperature on deck, ...	53.6°	53.6°
Temperature in fire room, ...	98°	108.9°
Temperature in engine room, ...	66.8°	70.1°
Temperature of injection water, ...	55°	55°
Temperature of discharge water, ...	85.9°	69.2°
Temperature of feed-water, ...	104.3°	161.4°

*† See remarks a little further on, in relation to the cut-off,

With respect to the result of the first trial, at the time the *Algonquin* ceased working, she had consumed coal at the rate of 1600 lbs. per hour, less *2525 lbs. charged to her, but not burned, together, it is said, with nearly a full allowance of 1600 lbs. on the fire room floor.

At the time of stopping, the counter of the *Algonquin* marked 47,454 revolutions, and the same time the *Winooski's* counter 47,362 revolutions, being a difference of 92 in favor of the former vessel. Allowing for the difference in time of commencing, the *Winooski* was a little ahead in turns, but she had also burned more coal than the *Algonquin*.

However, the report of the Naval Engineers on this trial states "that the economical performance of each was equal at the time of the failure of the machinery of the *Algonquin*," although, as has been already mentioned, we know, from personal examination, that the *Algonquin* actually made more revolutions than the *Winooski* with the same coal. Let it be assumed, in order to make a clear case, that the report of the Naval Engineers is correct, it will then be interesting to make a comparison, and see how the result stands with regard to the expansive principle.

Analyzing indicator diagrams, taken from both vessels during this late trial, it is seen that the back pressure against the piston of the *Algonquin*, due to the inferior vacuum in the condenser, is about 3.5 lbs. per square inch greater than the same pressure against the piston of the *Winooski*. So the *Algonquin's* engine, in addition to revolving a wheel of the same size, and at the same speed as that of the *Winooski*, it also had to overcome the constant extra resistance of 3.5 lbs. per square inch of the piston. As the mercurial column of the *Algonquin's* vacuum gauge vibrated through several inches, it may be that the estimate of the Board of its mean height, viz: 22 inches, is the nearest correct; however, we estimated it at 20 inches, but it makes no difference which is right, as the indicator diagrams show the exact mean back pressure against the pistons of both vessels, due to the condition of the vacuum in the respective condensers. The condenser gauge fitted to the *Winooski's* condensers, was one of Bourdon's, and the hand only vibrated enough to indicate that the communication to the condenser was unobstructed. Some indicator diagrams taken from the *Algonquin's* cylinder during the trial, show the effect of the back pressure against her piston—in excess of that of the *Winooski*—making the number of strokes per minute, stated by the Board, was to lessen the power of her engines upwards of 60 horses. And an average of several indicator diagrams, taken at intervals during the trial, shows the excessive back pressure in the *Algonquin's* cylinder was equal to a loss of dynamic effect of over 50 horses power. Then, taking the admission of the Board of Engineers that both vessels actually performed the same work with the same coal in turning

* 1600 lbs. was weighed out to each boat per hour; this was dumped in a heap, and used at discretion.

the paddle wheels, it follows, from this cause alone, that the *Algonquin* really developed 50 horses power more than the *Winooski*.*

It has been asserted by the Chief of the Steam Bureau, that a loss rather than a gain would have resulted to the *Algonquin* if the vacuum in her condenser had been equal to that in the *Winooski*'s. This, he said, would be effected in two ways, namely, the decrease in the temperature of the *Algonquin*'s feed-water due to a better vacuum, and the increased "cylinder condensation" also due to a better vacuum.

The usual calculation, however, shows that the loss from these causes would be but a small fraction of the gain in power which would have resulted to the *Algonquin*'s engine, had the vacuum in her condenser been equal to that in the condenser of the *Winooski*, viz: 27.65 to 28 inches of mercury—the more so as the comparatively high temperature of the *Algonquin*'s feed-water was not due entirely to the poor vacuum, but in a great measure to her feed-water heater. It is believed that at least 30° of the temperature of her feed-water was due to the heater. Another source of loss in the *Algonquin* was the independent circulating engine.

This engine has a cylinder 10 inches in diameter by 7 inches length of stroke; the steam is drawn directly from the boiler and follows the piston full stroke. This engine is attached directly to the axis of the centrifugal pump, and the number of revolutions it made was so great that they could not be accurately counted by the eye. The lowest estimate of the number of revolutions, made by several civilian engineers who saw it, was 400 per minute; the polished brass oil cup on the crank-pin looked like a wheel, so fast did it run.

Let us assume, for the sake of illustration, that it made only 250 per minute, and that the mean pressure of steam on its piston was 25 lbs. per square inch. When it is taken into consideration that the pressure in the *Algonquin*'s boilers was some 70 lbs. per square inch, and as the vacuum was deficient, this independent engine was driven to its utmost, this pressure is clearly under the true amount.

Therefore, calculating in the usual way, it is seen that this engine was working up to no less than 22 horse power.

Again: the piston of the main engine of the *Algonquin*, including clearance at the ends, was only moved through 2.6 times more space before the supply of steam from the boiler was cut off, than was moved through in the same time by the piston of the circulating engine. Hence, calculating the quantity of water which passed through this small engine in the form of steam—neglecting condensation—it is found to be about 22 per cent. of the total amount of water evaporated by the boilers of the *Algonquin*. It is, of course, hardly necessary to add that if this great quantity of steam had been put into the main cylinder, where it would have had its efficiency increased by

* Of course, a deduction must be made from this amount, on account of the lower temperature of the feed-water of *Algonquin*, had the vacuum been equal to *Winooski*'s.

expansion, the utter defeat of her competitor would have been the consequence.

The great difference in the power required to circulate the refrigerating water in these vessels, having been noticed at an early stage of the trial, Mr. Isherwood asserted that the power required to work the circulating pump of the *Winooski* "will not amount to one-fourth of one per cent. of the total power." The great disadvantage under which the *Algonquin* worked in this respect is therefore evident. According to this calculation, twenty times more power was required to perform this duty in the *Algonquin* than in the *Winooski*.

It now remains to mention the difference in the character of boilers of the two vessels, with respect to their relative economical evaporative power.

The proportion of the heating surface to the grate surface in the *Winooski's* boiler is 25 to 1; the consumption of coal during the trial [assuming 1600 lbs. per hour to have been consumed] was 8 lbs. per hour per square foot of grate surface, and .31 lbs. per hour per square foot of heating surface. Referring to an experiment made with a similar boiler in the U. S. "doubled-ender" *Eutaw*, it is seen that at the rate of combustion of 8.36 lbs. of coal per hour per square foot of grate surface, the evaporation was 9.28 lbs. of water from a temperature of 100° per lb. of coal consumed.

In the boilers of the *Algonquin* the ratio of heating to grate surface is 27.7 to 1. Assuming that 1600 lbs. of coal was burned each hour, the rate of consumption was 11.4 lbs. per hour per square foot of grate surface, and .42 lbs.* per hour per square foot of heating surface. With respect to the evaporative power of these boilers, it will be well, in the first place, to examine the disposition of the heating surface. This consisted almost solely of a series of inclined *water tubes* placed within the furnace, which was made correspondingly high; the superheating tubes are secured, one end in the crown sheet of the furnace, and the other in the shell of the boiler. Through these tubes the products of combustion pass and are collected by a water casing on which the smoke pipe is fitted. As these superheating tubes are quite short, (not over 26 inches long,) and lead straight from the furnace to the chimney, it is clear that, owing to the short distance the hot gases pass over the superheating surface before being discharged into the atmosphere, but little caloric can be imparted from them to the steam outside the superheating tubes. Again, as the lower ends of these tubes are immersed in water, not only will the tubes be cooled by the conducting power of the metal of the tube itself, but if there is the slightest priming the whole of the tubes will be covered with spray. For these reasons, it is evident that a more inefficient superheating apparatus could scarcely be devised. Those who have experience with superheating apparatus are aware how priming, if spray comes in contact with the superheating surface, destroys its efficiency as a superheater. As to the evaporative power under the conditions of the experiment, ample experience warrants that it at least cannot be placed higher than 8 lbs. of water evaporated for each pound of coal burned.

* Including the superheating surface.

The least that can be said for the vertical water tube boiler* of the *Winooski*, is that it is unsurpassed by any type of boiler in use for economic evaporative efficiency under the very favorable conditions of the trial; on the other hand, the boiler of the *Algonquin* may be classed as one of but ordinary economical evaporative power. Hence the steam as delivered to the *Algonquin* engine cost much more in coal than the steam delivered to the *Winooski* engine.

With regard to the superheating of the steam in the two vessels it may be mentioned, that thermometers, inserted in their respective steam pipes, indicated that the temperature was but very little above that which is due to the pressure. On the *Winooski*, the expedient was adopted of carrying the water in the boilers a considerable distance below the upper tube sheet, in order to superheat it by bringing the fire directly in contact with the upper portion of the tubes. This device fully compensated for any gain in this direction obtained on the *Algonquin* as before indicated.

Experiments on a duplicate of the boilers of *Winooski* show that there was no material decrease of evaporative efficiency by carrying the water at the distance below the tube sheet it was carried on the trial.

Yet with all these various sources of loss which did not exist in the *Winooski*, viz: the excessive back pressure in the cylinder, the great quantity of steam wasted by the circulating engine, the loss of effect due to the irregular velocity of the paddles, and the inferior economic evaporative efficiency of the boilers, the Board of Naval Engineers reported, "that the economical performance (*i. e.* work actually done) of the machinery of each was equal at the time of the failure of the machinery."†

The second economy trial was still more decisive in its results than the first. This is, no doubt, due to the fact that the engine of the *Algonquin* had been repacked and the valves ground in. The trial com-

* Whatever may be the deficiencies of this type of boiler with respect to absolute evaporative capacity, it is admitted that for economical evaporation at low rates of combustion, it is unsurpassed.

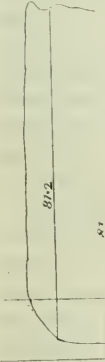
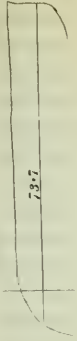
† On this head the London *Engineer* remarks: "Granting, then, that both engines used the same amount of fuel in doing the same work, in what, it will be asked, lies the superiority? In order to answer this we must first point out that this was not a test of actual economy; it was simply a test of relative economy. Again, Mr. Isherwood holds that the proper point at which to cut off is $\cdot 7$ of the stroke, and on this principle all the new screw engines of the American Navy have been designed. He admits that a slight saving may be effected—fifteen per cent., or thereabouts—by cutting off at this point, as compared with working the steam full stroke. He also states definitely that by cutting off at $\frac{4}{5}$ ths of the stroke, 'the loss of the economy in fuel alone reaches forty-four per cent. of the cost of the power when cutting off' at $\cdot 7$; that is to say, that an engine cutting off at $\frac{4}{5}$ ths is forty-four per cent. less economical than one cutting off at $\cdot 7$. In the face of this absurd statement we have Mr. Dickerson's very imperfect engine, cutting off very nearly at $\frac{4}{5}$ ths, burning precisely the same quantity of fuel as another engine cutting off at $\cdot 475$. It is also worthy of note that, although the Chief Engineer of the United States Navy pins his faith on this particular cut-off at $\cdot 7$, as being the most economical possible for all speeds of piston, for all pressures, and for non-condensing as well as condensing engines, he would not adopt it in the *Winooski*, but he did adopt a different grade, $\cdot 457$, which we, in this country, know to be about the best possible for ordinary condensing engines, with unjacketed cylinders and long strokes. On this point Mr. Isherwood is decidedly beaten."

menced October 23, 1865, at 5 o'clock, P. M. Owing to some misunderstanding between the rival engineers, the *Algonquin's* engine was stopped after it had run some 69 hours of the stipulated 96. Now, the Board of Naval Engineers report that "three hours from the commencement of the trial the fires were in steady action, and the machinery in proper working condition." During the succeeding forty-eight hours, the *Algonquin* gained about 1000 revolutions over the *Winooski*. This seems to be decisive as to the soundness of Mr. Isherwood's views on the subject of expansion, because 48 hours of uninterrupted trial, both vessels during that time consuming the same coal, is just as decisive in pointing out which way the scale inclined, whether for or against Mr. Isherwood's hypothesis on expansion, as though it had been extended over an indefinite period. And, as the power required to revolve the respective wheels varies as the cube of the number of revolutions made in a given time, it will be perceived how very decisive this last trial has been against Mr. Isherwood's theory. The reason why this 48 hours has been selected from the time occupied in performing this experiment, is that during that time the *Algonquin's* engine was operating well—as well as it could be expected to operate; while it is admitted by all that the superior engine of the *Winooski* works as well at the end as at the beginning of the trials, and for the purpose of scientific comparison it would be obviously improper to include that portion of the time during which the *Algonquin* was gradually breathing her last.

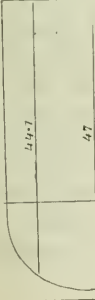
No doubt, taking the whole time into consideration, the tables of the Board are correct, but that proves nothing in relation to the question under discussion.

It will be noticed, that the point of cut-off of the *Winooski* is reported by the Board to be different in these two trials, and as the cut-off was not changed, and the indicator cards taken during the two trials are the same, it is necessary that this feature in the report should be explained. The Board report: "The point at which the steam was cut off in the cylinder of the *Winooski* was ascertained by 'hooking on' the eccentric rod and turning the engine by hand, noting exactly on the main guides the point at which the toe of the socket aft left the lifter on the lifting rod. This measurement gave 4 feet 10 inches for the upper stroke, and 6 feet for the lower stroke; which, as the stroke of the piston is 8 feet 9 inches, gave a mean of 0.619. The cut-off of the *Algonquin's* engine, not being a positive, one could not be so measured, but has been computed from the indicator diagrams."

Now, owing to the peculiar action of the *Winooski's* independent cut-off, (the one known as the Stevens,) the steam is practically cut off from the cylinder some time before the valve actually seats itself; for while the valve is almost touching its seat and moving at its *slowest* rate of speed—which is very slow indeed—the piston is moving at its *highest* rate of speed. Again, if the valve is deep on its conical bearing face, this distance is very considerable, *i. e.* the distance moved by the piston after the steam is practically cut off before the valve absolutely seats itself. However, to examine the indicator dia-



8.7



STEAMER ALGONQUIN OCT. 24TH 1865.

N^o 1
 Lower End of Cylinder 4.09 P.M.
 Revolutions per Min. 14
 Pressure of Steam 68
 Throttle Valve Wide Open
 Vacuum, Ins. 22"
 Temp. Hot Well 150°

STEAMER ALGONQUIN OCT. 25TH 1865.

N^o 1
 Upper End of Cylinder 3.15 A.M.
 Revolutions per Min. 14
 Pressure of Steam 72
 Throttle Valve Wide Open
 Vacuum, Ins. 22.5"
 Temp. Hot Well 150°

STEAMER WINOOSKI OCT. 24TH 1865.

N^o 2
 Upper End of Cylinder 12.30 P.M.
 Revolutions 13.5
 Steam 21
 Throttle 8
 Vacuum 27
 Hot Well 109°

STEAMER WINOOSKI OCT. 24TH 1865.

N^o 2
 Lower End of Cylinder 12.30 P.M.
 Revolutions 15
 Steam 27
 Throttle 8
 Vacuum 27
 Hot Well 109°

STEAMER ALGONQUIN OCT. 25TH 1865.

N^o 3
 Upper End of Cylinder 1 A.M.
 Revolutions per Min. 15.5
 Pressure of Steam 73
 Throttle Valve Wide Open
 Vacuum, Ins. 21"
 Temp. Hot Well 155°

STEAMER ALGONQUIN OCT. 24TH 1865.

N^o 3
 Lower End of Cylinder 3.15 A.M.
 Revolutions per Min. 16.3
 Pressure of Steam 63.5
 Throttle Valve Wide Open
 Vacuum, Ins. 21"
 Temp. Hot Well 170°

STEAMER WINOOSKI

N^o 4.
 Date & Hour 6 P.M. Jan. 22
 Which End of Cylinder Upper
 Revolutions per min. 16
 Pressure of Steam, in Barrels, in lbs. 35
 Position of Throttle Valve 8
 Vacuum per Gauge, in inches 26.5
 Temperature of Hot Well, Fato 105

STEAMER WINOOSKI

N^o 4
 Date & Hour 6.30 P.M. Jan. 22
 Which End of Cylinder Lower
 Revolutions per min. 16.5
 Pressure of Steam in Barrels in lbs. 35
 Position of Throttle Valve 8
 Vacuum per Gauge, in inches 27
 Temperature of Hot Well, Fato 105

grams (as was done in the case of the *Algonquin*) is the only true way to tell where the steam is practically cut off. Now, various indicator diagrams (copies of which are given) show the fact that the steam was cut off at about *four-tenths* of the stroke. Why the expedient of measuring the point of cut off adopted in the last trial was employed, does not appear. The cut-off was the same on both trials.

In estimating the effect of expansion, the loss by clearance at the commencement of the stroke is a very important point; the higher the pressure and the shorter the point of cut-off, the greater will be the loss of effect from these causes. Accordingly, in calculating the effect of the clearance in the case of these two vessels, it is found that the loss from this cause was greatest in the *Algonquin's* engine, not only because the steam was of four times greater density, (which makes one cubic foot in the *Algonquin's* clearance equal to four in the *Winooski's*), but also because the degree of expansion was very much greater.

Mr. Isherwood's opinion of the result of the well known Erie Expansion Experiments is summed up in the following extract from his report: "*If the point of cut-off be lessened to $\frac{4}{10}$ ths (about the point the *Algonquin* cut off during the trials) of the stroke, the loss of the economy of fuel alone reaches the enormous amount of 44 per centum of the cost of the power when cutting off at $\frac{7}{10}$ ths.*"

In other words, and as Mr. Isherwood has many times emphatically declared, cutting off at less than or beyond $\frac{7}{10}$ ths of the stroke of the piston will be followed by a decrease in efficiency. Seven tenths of the stroke is the point of maximum efficiency according to Mr. Isherwood.

And in relation to the gain by the use of superheated steam, this gentleman remarks, in his summation of the results of the Erie Experiments: "It has been abundantly proved that it is far more economical in the production of power to expend a given quantity of heat in the generation of steam from water, *than in superheating that steam out of contact with water.*"

On this point, without adducing the incontrovertible results of extended practice and experiment, both in this country and Europe, it will be sufficient to remark that a knowledge of elementary physical laws cannot fail to prove to any one that it is "far more economical in the production of power to expend a given quantity of heat," in heating steam out of contact with water, than "in the generation of steam from water."

After it has been demonstrated that a given weight of steam in the *Algonquin's* cylinder performed a much greater amount of work than the same weight of steam in cylinder of the *Winooski*, what becomes of Mr. Isherwood's $\frac{7}{10}$ ths cut-off theory? The more so, as in these trials, (see the indicator diagrams, Plate III.,) so far from hazarding a completion at the point of cut-off he assumes to be the most economical, he adopted the usual commercial point with that type of engine, viz: from four to five-tenths:

While on this point, we cannot refrain from remarking, that even supposing the Chief of the Bureau of Steam Engineering had much

stronger grounds to sustain this theory, he would scarcely have been justified in proportioning the engines of the entire screw navy in accordance with it. Indeed, even if results had sustained this wide departure from the most successful practice of the best engineers in the world, such a proceeding would scarcely be justified, but it is well known that the results of the machinery of the U. S. screw vessels fitted with engines planned at the Navy Department in accordance with this theory, have given results much below the average of naval practice, both here and in Europe.* It is a matter for regret that conditions of the innumerable and exceeding costly experiments which have been conducted by direction of the Navy Department during the past four or five years, have not been governed by the advice and experience of a Board composed of our best physicists and engineers, instead of depending solely on the wisdom of one man; had the course we have mentioned been adopted, it cannot be doubted that the results as regards the increase of our knowledge of steam engineering would have been very great.

But Mr. Isherwood has made these costly experiments—for the most part mere repetitions of each other—the basis of an endless amount of reasoning,† metaphysical reasoning, too, we may almost assert, by which he endeavors to explain the relation of cause and effect, instead of allowing the “experiments” to speak for themselves.

With respect to the rival engines, it should be remarked, that the *Winooski*'s is constructed on old and well tried plans; it is the engine which has so great celebrity throughout the world, as the American poppet valve expansive engine.

It was used long before our time and is one of the most marked triumphs of American engineering skill. Indeed, even the point of cut-off, where one would naturally suppose, if any where, a departure would be made from the average practice, was fixed at the usual point in American paddle-wheel engineering; in fact, at the usual point in the paddle-wheel practice of the world.

Hence, nobody, except one not posted in the antiquities of the profession, could suppose that there was anything new in the design of this engine.

* The machinery of the *Winooski* class (paddle vessels) does not materially differ from the usual practice, except that the cylinders are smaller than usual for the boiler power and speed of the piston. The following facts will enable those familiar with navigation to perceive that the performance of the *Winooski* on the late speed trial was not equal to the results usually attained with machinery of much less weight and with less boiler capacity. Length, 240 feet; breadth at load line, 35 feet; draft, (mean,) 8 feet 4 inches; greatest immersed section, 263·8 square feet; average pressure in boilers, 38 to 40 lbs. per square inch; average revolutions, 21·5; average speed, 11·6 knots; total weight of machinery, including water in boilers, 623,918 lbs.; without water, 541,718 lbs.

† The following extract from the London *Engineer* exhibits the opinion so generally entertained on this subject: “Mr. Isherwood's work is so well written, and the figures it contains are so skilfully prepared, and so apparently trustworthy, that many of the younger members of the profession, both here and abroad, have been misled, and others older and wiser have been inclined to doubt the evidence of their own senses and the experience of a lifetime, when opposed to the reasonings of a theorist. The Washington trial, (*Algonquin* and *Winooski*,) short as it was, has utterly demolished Mr. Isherwood's arguments, and proved to demonstration the accuracy of the principles adopted by our most successful engineers for years past.”

On the contrary, the machinery of the *Algonquin*, in those parts which govern the making, using, and condensing the steam, is full of novelties. Accordingly, a very mediocre result may be looked upon as a tolerably respectable performance. The contractor of the *Algonquin*, of course, relied on running his engine with a very short cut-off, against another engine cutting off at the point which Mr. Isherwood asserts is the most economical, viz: $\frac{7}{10}$ ths of the stroke. On the contrary, as will be seen by inspection of the indicator diagrams, he failed to put his theory to the test.

The diagrams marked Nos. 1 and 3 were taken from the *Algonquin's* cylinder during the dock trials with the *Winooski*; diagrams No. 2 were taken at the same time from the *Winooski's* cylinder, and diagrams No. 4 were also taken from the *Winooski* during a "dock trial" which occurred a few days previous to the trial on Long Island Sound.

By comparing these diagrams with such a diagram as would have been given if the steam had been expanded during but $\frac{3}{10}$ ths of the stroke, it will be seen how very far the measure of expansion shown by the *Winooski's* diagrams is from the theory of Mr. Isherwood. Of course, the *Winooski* would have given such a diagram, (i. e. one showing the steam to have been expanded during but $\frac{3}{10}$ ths of the stroke,) if the $\frac{7}{10}$ ths cut-off theory, which Mr. Isherwood claims to have established, at the expense of the government coal yard to be the point of maximum efficiency, had been put to the test. If this had been done, it is very plain what the result would have been; of course, the *Winooski* would have been beaten worse than she really was.*

The trial was, therefore, between an engine with a very short cut-off and of novel construction, and an engine constructed on old and well established plans, cutting off at the usual point. But, nevertheless, as has been shown, it has proved that Mr. Isherwood's conclusions in relation to his innumerable government expansion experiments are fallacious.

Notes on the Origin of Several Mechanical Inventions, and their subsequent application to different purposes. By J. C. DYER.

From Newton's London Journal of Arts, January, 1866.

The Employment of Steel for Transferring Engravings.—At the beginning of this century, upon the death of Washington, medals to commemorate that event being called for, Mr. Jacob Perkins (then a silversmith at Newburyport, near Boston,) undertook to supply them, and, as they were required in large numbers speedily, he devised a summary process of transferring the engraved design, from prepared steel dies, or stamps, by which he obtained several from one original die, and thus a vast number of medals were rapidly produced. Shortly after, Mr. Perkins applied the same principle of transferring engravings for bank notes, on which very elaborate designs were printed, to prevent or render their being forged very difficult by the hand of the engraver. To effect this, he procured cast steel plates, and de-

* The pressures opposite the ordinates in the diagrams were measured from the original. The diagrams are two-thirds the original size. "Position of throttle valve 8," diagrams No. 4, means, wide open.

carbonated their surfaces to the depth of about one-sixteenth of an inch, which were thus converted into *very soft and pure iron*; the letters and designs for the notes being then engraved upon them, they were case-hardened and tempered for use, but in lieu of printing from these plates they were used as dies for making others to print with. His next process was to prepare a cast steel cylinder, which, in like manner, was decarbonated at the surface, and then, under a strong traversing pressure, it was rolled over the letters and figures engraved on the hardened plate, and these engravings were taken up in relief on the surface of the soft cylinder. This cylinder being then hardened and tempered, was used to transfer, by means of the same traversing pressure, the entire work upon its surface, to any number of copper or soft steel plates for printing with.

The adoption of this plan by several banks, for having very elaborate engravings on their notes, turned the counterfeiters upon other banks, whose notes would be so much more readily forged, which led to an extended demand by the other banks.

In the year 1809 Mr. Perkins communicated to me the details of his process of transferring engravings, with a view to having the invention patented in England for our joint account. From the success of his plan in America its adoption here was anticipated, and still further development of it looked for from the higher state of the graphic arts in London. With this view I took out patents, and minutely specified "the method of carrying the invention into effect." A very beautiful design was then obtained from the classic pencil of the late Sir R. Smirk, R. A., which was engraved by Reimback, on prepared steel, for printing bank notes. But I could not succeed at that time to induce the Bank of England or any other bank to adopt the plan, nor could the booksellers then be made to perceive the importance of the transferring system for illustrating books, for which it has since been so extensively used. The time had not arrived when public attention could be drawn to the bank note forgeries as a national evil, and the disgrace of hanging men for a feat so readily performed as that of forging the one-pound notes then in general circulation. If any excuse can be offered for this apathy, it may be said that the passions and interests connected with the war, together with those yet more embarrassing that arose from the transitions from war to peace, caused such disturbances in the circulating medium and in the general interests of commerce and industry, that it became very difficult to awaken public attention to the great scandal of relying solely upon the gallows for preventing forgeries.

It has been above shown that Perkins' invention was not for engraving on steel plates for printing, nor for engraving upon steel at all, but rather for engraving on soft iron of homogeneous structure. It was found that all wrought iron is more or less fibrous and unfit to receive delicate engravings, and that by decarbonating the surface of cast steel a pure iron surface was obtained, and this being engraved on, was case-hardened and used for transferring and printing as before stated. This should be kept in view, because many persons have supposed that the invention of Perkins was merely the substitution of

steel in the place of copper for engraving upon ; such a substitution of the one metal for the other would not be an invention in any fair sense of the word. But his method of obtaining soft surfaces to receive the work, converting these surfaces back into steel, and then transferring the engravings to other plates for printing, comprised together a series of novel processes which confer lasting honor upon the inventor.

After the transition period, having better hopes of success, I recommended Mr. Perkins to come over himself and explain his system, and aid the artists here in putting it into operation. Accordingly, in the year 1820, Mr. Perkins came to England, and, being over sanguine, brought a large staff of able artists, mechanics, &c., but he could not bring any money to aid in establishing his intended works in London. He had assumed that capital could always be obtained in England for conducting any safe and profitable schemes. Now, the matter of proving his to be such was not easy to establish with the *moneyed class* ; so to me alone, not of that class, he had to look for the entire expenses of his mission, and this I could only bear for a few months. After some time, the late Mr. Charles Heath, the eminent engraver, was induced to join Mr. Perkins and become a partner in the engraving works which were then commenced in Fleet Street, and are still continued by their successors.

Besides the printing on paper, Mr. Perkins' system of transferring has been since very extensively employed for calico printing, and in later years we have also seen his process employed to a vast extent in many other departments of the graphic art, such as post-office and receipt stamps, and other prints that are required in greater numbers than could be produced by other means than steel plates or stamps. His system of engraving on steel has at length become a great artistic power, the wide-spread increase of which has given employment to labor and capital to a vast extent in the several branches of art before stated, and from which I believe many large fortunes have been made, but little other than "toil and trouble" ever accrued to the inventor of them.

When any important discoveries in physical science are made they never die, whatever may chance to their authors. The new facts brought before the public go forth like seeds cast upon a fertile soil, yielding the fruits of continual progress among the families of men who seek improvement. It seems only just, then, that each generation should transmit to the next some record of the names of those contemporaries to whose genius and talents all nations are indebted for such discoveries. Wherefore, in addition to the four distinguished inventors brought to the notice of this Society in my former papers, I have in the present one aimed to place that of Jacob Perkins as a worthy contributor to the advance of those branches of art to which his inventions have been applied.

On the Compression of Water.—In tracing the progress of steel engraving, I had no thought of giving a general account of Mr. Perkins' researches in physical science, yet it may not be out of place to notice one or two other of his discoveries.

1. His experiments on the compressibility of water (made some time before he left America) were to test the correctness of the doctrine founded on the Florentine experiments, that water was a non-elastic body, which was then generally taught in the schools and elementary works. At that time Mr. Perkins had never heard of the experiments of Canton (made some fifty years before) which had established the compressibility of water. Although by Mr. Perkins' experiments its discovery was not *strictly new*, yet they were of high scientific value, because of the widely different compressing forces employed by him and by Canton, the latter having applied the pressure from half an atmosphere to two atmospheres, say from seven and a half to thirty pounds a square inch, whilst that employed by Perkins was from fifty to four hundred atmospheres, or from 750 lbs. to 6000 lbs. per inch. The same rate of compression appeared in all his experiments, which corresponded with that shown by Canton's experiments, and in all of which the water was compressed in volume directly as the compressing forces.

The apparatus employed by Perkins was first a cast iron cylinder, about three inches thick, with a movable top of equal strength; this, filled with water, had a force pump (as in the hydraulic press) to measure the pressure within by the leverage and size of the induction pipe. 2d. A small brass cylinder, with a piston to slide in it, water-tight, about three-quarters of an inch diameter, and to have a column of water ten inches long under the piston. The piston rod, graduated to divisions of a hundred to the inch, had a sliding ring on it, to be pressed upon the rod as it was forced down upon the enclosed water, thus marking in the hundredths of an inch the descent of the rod; the brass cylinder being under the same pressure inside and out, was not subject to any strain to alter its capacity. 3d. When the external pressure was removed, the water in the brass cylinder expanding to its original length and raising the piston rod, would, of course, mark the greatest compression effected. In each experiment the diminished bulk of water was directly as the pressure applied, and under the pressure of 100 atmospheres, the bulk of the water was reduced one part in a hundred, and, as before mentioned, this rate proved to be the same as that shown by the experiments of Canton. Some time after Professor Oersted made similar experiments, by employing a stout glass vessel and using a column of mercury to give the pressure, having the like inside cylinder of Perkins to mark the result, which confirmed the same rate as that shown by Perkins and Canton.

On Perkins' Steam Gun.—Mr. Perkins conceived the idea of employing steam at a very high pressure for discharging projectiles with greater rapidity and effect than could be done by the common use of gunpowder. To effect this object, he devised a plan for heating water more intensely than could be done by any boilers then known, viz: that of employing a great number of iron or copper tubes, with their ends fastened into plates, with chambers, or cavities, for receiving the water at one end and emitting the steam at the other.

This apparatus was placed in the midst of a furnace for the heat to

act directly on the water in the tubes, and thus, as Mr. Perkins phrases it, the water could be made red-hot, and flash into steam with a force exceeding that of gunpowder. Then a gun barrel, with its breech opposite the valve opening from the steam chamber, and an apparatus for conducting the balls into the space between the breech of the barrel and the outlet of the steam, and the valve opening at the same time, the steam issued and propelled the balls through the gun in rapid succession with a force about equal to common powder, which could be continued as long as the heat of the furnace could keep up the pressure. He found that from fifty to one hundred balls per minute were shot forth about one hundred yards to a target, with a force nearly equal to that of a common musket, and, of course, by having ten such guns fixed to the same furnace, from 500 to 1000 balls might be discharged per minute. His experiments were witnessed by the Duke of Wellington and many other eminent men, who took much interest in them.

The non-adoption of his system arose from several radical defects in it—first, the danger from fire of having such a cumbrous furnace on a ship; second, the time required to get up the steam in case of sudden encounter with an enemy, which might lead to a surrender before a shot could be thrown from the steam battery; third, by unequal heating, the tubes sometimes gave way, allowing the water to escape, and though the quantity being small would not cause explosions, leaks would deaden the fire and stop the action of the guns, and any suspension in the midst of action must be fatal to the ship using such a weapon. Still, the after interest attached to the plan of the tubular boilers came from reversing the scheme used by Perkins, viz: employing the tubes as flues for the fire, to convey the heat through the tubes to the water surrounding; then, in an outer boiler, by this method, without damaging the tubes, it is found that high-pressure steam can be employed with safety and advantage, so that Mr. Perkins' invention was not barren to the outer world, since his tubular boilers led to their extended employment in railway and steamboat engines, and were, I believe, first employed by Stephenson a few years after the steam-gun experiments had been put *hors de combat*.

NOTE.—Although it is needless to describe the process of case-hardening, so generally known, it may be as well to explain that of decarbonizing the steel plates for engraving. This process is as follows: The prepared steel plates are placed in a cast iron box, and covered about an inch deep with an oxide of iron, prepared by subjecting iron filings to an alternate wetting and drying until they are mostly converted into red oxide. Over this covering a clay luting is placed, so as to exclude the air, and the box is then placed in a furnace and kept at a red heat for about sixty hours, when the oxide in contact with the steel will have taken up the carbon from its surface to the depth of about one-sixteenth of an inch, and thus converted the surface into pure iron, as mentioned in the text.

Proc. Manchester Philos. Soc.

Fire-damp in Coal Mines.

From the London Chemical News, No. 309.

Mr. G. F. Ansell has sent to a contemporary the following account of his mode of applying the law of diffusion to the indication of the

presence and amount of fire-damp: "Gases would appear to be formed of minute atoms, which have motion amongst themselves, rapid or slow, in proportion to the density of the gas experimented upon. This motion of the atoms is not confined to each individual gas, but the atoms of one gas pass freely through and amongst the atoms of another gas, thus producing a perfect mixture of any two gases which are so circumstanced as to admit of the requisite motion. The atoms of a gas are not arrested in their motion by septa of porous substances, that is, substances impervious in the ordinary acceptation, but not absolutely so. Such substances include thin india rubber, artificially prepared graphite, unglazed earthenware, &c. The law of diffusion, as educed by Mr. Thomas Graham, F.R.S., would appear to be as follows: A gas diffuses into another gas or into space in the inverse ratio to the square root of its density. In the application of this law to the indication of the presence of fire-damp, I follow my original thought and use india rubber. I fill a balloon of thin india rubber (just such a balloon as that used by children for a play-thing) with atmospheric air, and I place it under a lever. If now the apparatus be carried into a mine containing fire-damp, the fire-damp diffuses into the balloon, in accordance with the above law, quicker than the atmospheric air diffuses out from the balloon, and the result is that there is an increase of volume within the balloon, and this causes expansion, just as would occur if so much air was forced into it. I cause this increase of size to move a lever, and thereby to make a galvanic circuit, and so to telegraph to a distance, while it also rings a bell on the spot. This particular arrangement is intended to give warning of a slow accumulation of fire-damp, and in practice it answers perfectly, giving at each interval of an hour the increasing amount per cent. of fire-damp present at that part of the mine. Supposing the atmosphere, then, to remain without alteration, the balloon remains of the same size; consequently the alarum would ring continuously for several days; but if the mine were purified, the balloon would shrink in consequence of diffusion, and the alarum would cease. If it be desired to give instant notice to the men at work, or to the people above ground, from the working place I use a porous battery cell, which, with a small column of mercury, gives warning in a few seconds of a sudden irruption of fire-damp. The action of this instrument is so immediate that, unless seen, it would appear incredible; it is, nevertheless, trustworthy and certain. Supposing the atmosphere which has caused the indication to remain unaltered, then the instrument empties itself by effusion, and the indicator returns to the original zero, and remains at that point until the mine is ventilated, when the indicator retires from zero, thus indicating the purification of the dangerous place. These remarks also apply to the pocket instrument described below. The instruments above spoken of are intended to give warning alone; but if it be desired for the information of viewers, inspectors, owners, and others to ascertain the amount per cent. of fire-damp present in the air of mines, I vary the form of my apparatus, but the most convenient form is that which is assumed in the small aneroid barometer for

the waistcoat pocket. The mercurial barometer, when fitted with the necessary accompaniments, gives very satisfactory results, as also does a column of mercury not representing a barometer. As regards the aneroid barometer, I remove the brass back, and replace it by a piece of porous tile—the ordinary biscuit-ware of Wedgewood. In my first experiments I used a piece of a broken flower-pot, which gave as good result as could be wished for. The instrument so completed, with a few additional and purely mechanical arrangements, which I would describe were there space in this letter, may be used as an ordinary aneroid barometer, but at the time of using it, to tell the amount of fire-damp present, it is necessary to close a valve by a small screw. Then having read the point at which the barometer stands, and noting this as the zero to remove a brass cap, which protects the porous tile, and if there be any fire-damp present the hand travels over the face of the dial, because the diffusion of the fire-damp into the chamber of the aneroid barometer causes an increased volume, which, being compelled to occupy a fixed space, causes pressure on the partly exhausted chamber within that space, and thus causes the hand to move over the face of the dial, indicating unfailingly the amount per cent. of explosive gas. In round numbers, 1 per cent. of gas is equal to $\cdot 01$ inch, and 10 per cent. of gas to $0\cdot 10$ inch on the aneroid barometer. The following results were obtained in the presence of experienced miners. I will, for this occasion, call my indicator an aneroid barometer: Aneroid barometer indicated $1\cdot 50$ per cent. of fire-damp; the Davy lamp gave no indication. Aneroid barometer indicated $3\cdot 00$ per cent. of fire-damp; the gas could be detected by the Davy lamp, which gave a small pale-blue flame. Aneroid barometer indicated $8\ 00$ per cent. of fire-damp; the Davy lamp exploded feebly. Aneroid barometer indicated $10\cdot 00$ per cent. of fire-damp; the Davy lamp exploded fiercely. Aneroid barometer indicated $6\cdot 00$ per cent. of fire-damp; the Davy lamp did not explode, but flame elongated greatly."

Specific Gravity of the Ocean and Sea Temperature.

From the London Reader, September, 1865.

The twelfth number of *The Meteorological Papers*, published by the authority of the Board of Trade, which we have just received, contains an important paper under the above title, in which is collected together a mass of valuable facts.

The observations of specific gravity, exceeding 50,000 in number, have, in every case, been reduced to the temperature of 62° . All the observations in each square of 10° of latitude and longitude have been collected and meaned; and these means, both specific gravities and temperatures, are shown on an outline chart of the world.

Atlantic.—The mean specific gravity of the whole of the North Atlantic, from the Equator to latitude 50° , is $1\cdot 02664$, while that of the South Atlantic, between the corresponding parallels, is $1\cdot 02676$, showing an excess on the side of the waters south of the Equator, but only

of $\cdot 00012$. The accession of the River Plate has considerable influence in diminishing the density of the sea in its vicinity, and by omitting all observations above 30° north and 30° south, the mean densities become, respectively, $1\cdot 0267$ and $1\cdot 0271$; that is to say, between the Equator and 30° the southern waters are heavier than the northern by $\cdot 0004$. This difference is less than has hitherto been generally supposed, and even *this* exists only between the Equator and 20° , and is chiefly occasioned by the greatly diminished density of the water between the Equator and 10° north in the belt of equatorial calms and rains. Though but little *heavier*, the South Atlantic is decidedly *colder* than the North, nearly 5° , their mean temperatures being $71^\circ\cdot 6$ and $66^\circ\cdot 7$, respectively, and that this difference is tolerably uniform, parallel for parallel, is rendered evident by some thermal curves which accompany the paper. Changes of temperature in sea-water are frequently abrupt. When H. M. S. *Nile* was going from Halifax to Bermuda, in May, 1861, Admiral Milne found the temperature 70° at the bow, while only 40° at the stern, as he entered the Gulf Stream. In illustration of the effect of heavy rains, in at least temporarily diminishing the specific gravity of the surface, a most remarkable instance was observed by Dr. C. K. Ord, of H. M. S. *Hermes* when that ship was lying in Simon's Bay, in August, 1859. On the 4th of that month, at 9 A. M., the specific gravity was $1\cdot 0266$, and in an hour it was reduced by the heavy rain that fell to $1\cdot 0193$, the water becoming "brown in color, merely brackish in taste, and its current setting distinctly outwards." By noon the density had increased to $1\cdot 0253$, and at 3 P. M. the surface had recovered its former density of $1\cdot 0266$. The next day the specific gravity was again reduced by heavy rain, and again rose.

Mediterranean.—The mean specific gravity of the whole of the Mediterranean, derived from about 600 observations, is $1\cdot 0289$. The mean density increases gradually from west to east; the observations to the west of longitude 10° east giving a mean density of $1\cdot 0286$, while between 10° east and 30° east the mean is $1\cdot 0291$, showing an excess of $\cdot 0005$ on the side of the eastern half of the sea. The average temperature at the surface is $67^\circ\cdot 3$, (the mean of *all* observations.) The highest temperature recorded is 79° , and the lowest recorded is 53° .

Dardanelles and Black Sea.—The Peninsular and Oriental Company's steamer *Colombo*, while passing through the Straits of the Black Sea, found the specific gravity decrease from $1\cdot 0278$ to $1\cdot 0162$. The mean of all the observations in the Black Sea (nearly 200) shows an average density of only $1\cdot 0143$; the maximum recorded is $1\cdot 0209$; the minimum* $1\cdot 0114$. The large influx of fresh water from the great rivers which discharge themselves into the Black Sea, is no doubt the cause of its diminished density, as compared with the Mediterranean. Its mean temperature is $56^\circ\cdot 8$, or $10^\circ\cdot 5$ lower than that of the Mediterranean.

North Sea and Baltic.—There is a very marked difference between

* Except off the mouths of the rivers.

the mean densities of the North Sea and the Baltic; for while the density of the former differs but little from that of the Atlantic Ocean generally, the specific gravity of the Baltic, as derived from about 100 observations, is even less than that of the Black Sea.

North Sea, . . .	Mean specific gravity, . . .	1.0261
	Maximum " . . .	1.0280
	Minimum " . . .	1.0199
Baltic, . . .	Mean specific gravity, . . .	1.0086
	Maximum " . . .	1.0232
	Minimum " . . .	1.0003

The mean of the observations in the western half of the sea (longitude 10° to 20° east) is 1.0112, while the observations to the east of longitude 20° show a mean density of only 1.0042. The temperature of the water appears to decrease eastward, but the observations are not sufficiently numerous to be of *much* value.

Pacific.—It is remarkable that, although the waters of the North and South Atlantic do not, upon the whole, appear to differ much in density from each other, yet the specific gravity of the South Pacific does seem to exceed that of the North, parallel for parallel. As in the case of the Atlantic, the mean surface temperature of the North Pacific exceeds that of the South, but the excess is neither so great nor so uniform. It should be remembered, however, that the Pacific observations are not so numerous as those made in the Atlantic, nor do they extend over quite the whole surface of the ocean. Taking the same limits as in the Atlantic, namely, 50° north and 50° south, the specific gravity of the North Pacific is to that of the South Pacific as 1.0254 to 1.0265, an excess of .0011 on the side of the South. The mean temperature of the North Pacific is $69^{\circ}\cdot 9$, (as far as present observations go;) that of the South is $67^{\circ}\cdot 7$, two degrees lower. The limits of longitude adopted in calculating these averages for the Pacific are 70° west and 140° east. Of the three oceans south of the Equator, the Atlantic, the Pacific, and the Indian, the Atlantic is the heaviest and the coldest; while the Indian is the lightest and the warmest, and the Pacific is between the two, as below.

South Atlantic, . .	Specific gravity, . . .	1.02676
	Temperature, . . .	$66^{\circ}\cdot 66$
South Pacific, . .	Specific gravity, . . .	1.02658
	Temperature, . . .	$67^{\circ}\cdot 70$
South Indian, . .	Specific gravity, . . .	1.02630
	Temperature, . . .	$69^{\circ}\cdot 28$

The North Atlantic *appears* to be both heavier and warmer than the North Pacific, but observations are wanting in the middle of the Pacific, where the density is probably greater than in other parts of that ocean. The result of the observations, as far as they go, is as follows:

North Atlantic, . .	Specific gravity, . . .	1.02664
	Temperature, . . .	$71^{\circ}\cdot 56$
North Pacific, . .	Specific gravity, . . .	1.02548
	Temperature, . . .	$69^{\circ}\cdot 49$

From its local peculiarities, the Indian Ocean, north of the Equator, cannot be compared with either the Atlantic or Pacific.

Sea of Japan, Yellow Sea, &c.—The density of the water (at surface) in the neighborhood of the Japan Islands and near the east coast of China and Chinese Tartary is somewhat variable. The greatest recorded in these seas is 1.0354 , found in $40^{\circ} 40'$ north, $138^{\circ} 6'$ east; but upon the whole the mean specific gravity is not high; and near the mouths of the larger river, especially in the Yang-tse-Kiang, it is very low indeed. Near the mouth of the Peiho also it was on one occasion found to be as low as 1.0053 . The sea-water temperatures generally appear rather high for the latitudes. The range of temperature, especially near the coast, is considerable. In the Gulf of Pe-Chili a range of 52° has been observed, 82° being the highest and 30° the lowest temperature recorded. The occasionally very low temperatures in this locality seem to be caused by the ice brought down by the Peiho River.

Red Sea.—The mean of some 200 observations gives 1.0286 as the mean density of the Red Sea. The density seems to be greatest in the northern parts of the sea, and to decrease gradually southwards towards Aden. The maximum observed is 1.0321 , in the Bay of Suez; the minimum 1.0252 , near Aden. Dividing the sea into two parts, north and south latitude 20° , we have the following result:

Mean density of the whole (as above),	.	.	.	1.0286
“ “ northern half,	.	.	.	1.0297
“ “ southern half,	.	.	.	1.0272

being an excess of $.0025$ on the side of northern half. The mean temperature of the Red Sea is $79^{\circ}.3$. Above latitude 20° it is $77^{\circ}.4$, and (the mean of the observations) below that latitude is $81^{\circ}.5$. The highest temperature recorded is $94^{\circ}.$ * Temperatures as high as 90° occur not unfrequently. The lowest temperature reported is $64^{\circ}.$ †

Indian Ocean and adjacent Seas.—In the Indian Ocean, including under that head the sea as far as 50° south and 140° east, the region (or line) of lowest specific gravity appears to be near the Equator, or a little to the south of it, whereas, in both the Atlantic and Pacific, the line of least density is to the north of the Equator in the belt of equatorial rains and calms. There is a marked decrease in density towards the east in the Bay of Bengal and towards Sumatra, occasioned no doubt by the accession of the fresh water from the rivers Ganges, Mahanuddy, and Irawaddy; but taking the means of zones of 10° there is but little difference in either the specific gravity or temperature from 20° north to 20° south. In the neighborhood of Sumatra and Java, in Banca, Sunda, and Gaspar Straits, the specific gravity is exceedingly variable. Though the specific gravity of the South Indian Ocean is less on the whole than that either of the South Atlantic or the South Pacific, some of the highest densities on record have been found in the South Indian. Captain Heddle of the *Calliance*, when going from Melbourne to Calcutta, between 30° and 10° south latitude, 100° and 90° east longitude, found two of 1.0349 and

* Steamer *European* at Aden, September 2, 1857. (Captain Maury mentions 95° as a not uncommon temperature in the Red Sea.)

† H. M. S. *Cyclops*.

1.0362, respectively. The last is the highest observation (well authenticated) on record, with the exception of Captain Harrington's 1.0442 to the southward of Australia.

The paper concludes with the following short summary of results: In conclusion, the result of the whole inquiry serves to show that the chief differences in oceanic specific gravity arise from local or special circumstances. It is high in regions where evaporation is rapid, as in the trade-winds, and low in those parts of the ocean where much rain falls. It is highest of all (on the average) in arms of the sea, such as the Red Sea, where there are no rivers and but little rain; and lowest near the mouths of great rivers, such as the St. Lawrence or the Plate, or in seas like the Black Sea and the Baltic, where the accession of fresh water is great. It is low also in high latitude in the vicinity of ice. The highest surface temperature anywhere recorded is 94° in the Red Sea near Aden. The highest surface temperatures recorded elsewhere* are 88° and 89° . These have been found not unfrequently in the Indian Ocean near the Equator. Captain Maury speaks of a temperature of 95° as being not uncommon in the Red Sea, but there is no record here of any temperature above 94° .

On some of the most Important Chemical Discoveries made within the last Two Years. By Dr. F. CRACE CALVERT, F.R.S., F.C.S.

LECTURE I.

Continued from page 202.

From the London Journal of the Society of Arts, No. 671.

The next discovery to which I desire to draw your attention is still in its infancy; but I am induced to refer to it from two considerations. The first, that it may render great service to society by enabling us to preserve the lives of many thousands of our fellow-creatures in our coal mines and other underground works, and, also, because it is a beautiful illustration of the amount of knowledge that a man requires at the present day either to understand or appreciate fully the discoveries of others, or to enable him to attempt any original invention of his own. Unless a person possesses the rudiments of the leading sciences of the day he will never be anything but an imitator, and will never succeed in improving the inventions already made. It is certainly most interesting to witness how the most abstruse branches of science are brought to bear on arts and manufactures, and no better example can be given than the application of electricity under various forms to what is commonly called the telegraph. The invention which I am about to bring to your notice is due to M. Dumas, a young French engineer, and to M. Brequet, of Paris, who is also practically connected with telegraphy. To enable these gentlemen to carry out their discovery they have had to study, and be perfectly acquainted with, the researches of many of the most eminent men that science has produced during the last half century. Thus they employ the galvanic battery which was discovered by Galvani, and perfected by many

* With the exception of a temperature of 91° , once recorded in square 62.

philosophers, until brought at last to its present perfection. They use a mixture of bichromate of potash and sulphuric acid in a Bunsen battery. They have also had recourse to magneto-electricity, first discovered by Faraday, and brought to its present perfection by the researches of MM. Nobili, Mason, Becquerel, Joule, and others, and to enable them to construct their apparatus they have applied, with great ingenuity, the inductive coil, the result of many successive discoveries, and brought to great perfection by Ruhmkorff, the vibrating interrupter of Dancer, and also the condenser of Fiquier. Further, they must have had the knowledge of the stratified light and the application of it by Gassiot: the fluorescence of light by Stokes and Becquerel, and their applications to glass by Geissler. All these facts prove the correctness of my statement, how vast is the amount of knowledge required to make a little discovery. The apparatus invented by these gentlemen is portable, for a miner carries on his back the above-mentioned galvanic battery, and this generates the force required, which is multiplied, increased, and brought to light by the Ruhmkorff coil, which is also confined in the same leather case, occupying only six inches; the magneto-electricity passes through wires covered by vulcanized india rubber, and these are in connexion with a thick glass tube, in which a vacuum has been made, and this contains a fluorescent tube of Geissler, which becomes luminous or fluorescent by the passage of the electricity through it, generated by the coil and the battery.

Although both light and electricity are most interesting subjects, and could well be made the subject of many lectures, still I am bound to leave them on one side, and draw your attention to other facts deserving of notice. It is well known to all chemists and philosophers that matter has a great tendency to assume a geometrical or crystalline form, and that whenever the atoms of matter are sufficiently free for molecular attraction to have its full influences, attraction between the atoms of matter takes place, and gives birth to well defined crystals. The following examples can be cited: The slow condensation of the vapor of iodine, which gives rise to well defined crystals, as well as those of camphor and other volatile bodies. When sulphur, bismuth, and other substances are melted, and allowed to cool slowly, and the excess of the fluid remaining among the crystals is poured off, well defined crystals are found to exist in the mass, which apparently would have disappeared had not the excess of fluids been poured off, for in this case the molecules of the remaining fluid mass would have solidified among the crystals, and would have prevented the observer from seeing that the molecules when freed in the fused mass had assumed a crystalline form. The tendency of molecules to assume a geometrical form presents in many instances curious phenomena. Thus, for example, a vessel may contain acetic and carbolic acids; and if, say at a temperature of 40° or 50° , a crystal of either of those substances is placed in contact with its own fluid, the entire bulk of fluid passes in a few seconds into a solid crystalline mass. The manifestation of that force is also beautifully illustrated in the following in-

stance: If a tin plate be heated to a moderate temperature, and a drop of water be allowed to fall on its surface, and the plate be dipped for a few minutes into weak muriatic acid, it will be observed that the whole surface of the plate is affected, and that where the water fell it has assumed a most beautifully waved and iridescent surface. If this surface be examined under the microscope it will be found that under the influence of the vibrations generated by the cold fluid falling upon the heated plate, the mass of molecules have passed from their amorphous condition to that of a crystallized one. We all know this alteration in the tin-plate surface was particularly applied many years ago to produce variegated surfaces on our tea trays and other similar domestic vessels. It should also be stated that this effect was greatly enhanced by the skilful application of colored varnishes, which increased the value of the mercantile article. This discovery, which is due to an eminent chemist of the name of Prout, clearly proves, as those before cited, the power which matter has to assume a crystalline form. I cannot, however, refrain from adding the following instances, in which the mere vibration of particles of matter is sufficient to change amorphous bodies into crystalline ones. The first is that which often takes place in the iron used on railways. The most striking example is that of the iron links used to unite wagons where it is found that the fibrous tenacious link made of malleable iron is transformed into a crystallized brittle link by the constant vibration it is subjected to by railway traffic. Another example is that shown by the peculiar action exercised by intense cold on the molecular state of iron, as shown by the brittleness of the metal in Russia and other cold climates; this was the case in December, 1859, in England, when, as will be remembered with regret, many railway accidents occurred, owing to the rails becoming crystallized and brittle.

The power which molecules have to assume a crystalline form has recently been the study of M. F. Kuhlmann, an eminent chemist of Lisle, and he has given to that force the name "crystallogenic." I shall endeavor to lay before you a short epitome of his researches, which are not only interesting in a scientific point of view, but also in consequence of the mode in which he has applied it in connexion with arts and manufactures; and those who take an especial interest in the matter will read with pleasure his researches in the *Comptes Rendus de l'Académie des Sciences de Paris*. M. Kuhlmann, having mixed a certain class of substances which crystallized with facility, such as mannite, sulphate of zinc, iron, copper, with a thick solution of gum, or any other substances interfering with the free crystallization of these substances, and having spread the mixtures on glass, he found, by exposing such prepared plates to the atmosphere, that gradually the water would evaporate, leaving a dry mass, in which could be observed most beautiful arborizations. Each of the solutions will produce a well defined design which is not always identical, although operating under the same circumstances. Still they assume very similar forms, being in some instances that of stars, and in others that of leaves and wreaths. These modifications are obtained by the

strength of the solution, the nature of the salt, and the mode of preparation. Kuhlmann further observed, that if amorphous substances, such as magnesia and sesquioxide of iron, or chromium, be mixed with bodies susceptible of crystallization, and these added to a gummy fluid, the amorphous particles are drawn into the crystallizing substances and follow the outlines; and if these are produced on surfaces, such as glass or porcelain, and heat applied, the gummy matter will be destroyed or volatilized, and the crystalline medium and the amorphous substances become incorporated and fixed in the porcelain, reproducing on its surface a crystallogenic design. These researches, which I have the pleasure to lay before you will show you the probability of carrying out these results to a satisfactory issue. Of course, the glass or porcelain manufacturer will easily understand that he will have to use borax or phosphate of soda or other flux, as a crystallizing medium, if he wants to produce in his art the results I have stated. M. Kuhlmann has applied his crystallogenic process with great success to photography, and also to the art of engraving metals. As the latter may have some interest, I will give you an outline of his process. It consists in producing a crystallogenic design on the surface of an iron or copper plate, and then applying on the so prepared surface—say a sheet of lead or copper—and submitting them to high pressure when the design would be impressed upon the plate. The embossed plates, by being placed in a prepared solution, and in connexion with a galvanic current, will easily give birth to a *fac-simile* in relief, which can be used as a printing surface. It is with pleasure that I am able to state that though I part with these interesting researches for the present, I shall have the satisfaction of referring to them again in a subsequent part of this course of lectures, when I shall speak of some researches of this gentleman which have a more immediate bearing on the progress of science.

It has been for a long time a disputed question whether the stained windows we all admire in old cathedrals could be restored in such a way as to resume the brilliancy they had at the time they were placed there by the artists. At all events there is now no doubt that this can be effected by the process discovered by my eminent master, M. E. Chevreul, as is proved by the application of it in connexion with the restoration of stained windows existing in a well known church in Paris—that from which the tocsin of St. Bartholomew was sounded—“St. Germain des Près.” The process devised by M. Chevreul is highly practical. It consists in removing the stained glass from the windows, and dipping it for several days, first, in a weak solution of carbonate of soda of a specific gravity of 1.068, then washing it, and dipping it for several hours in a solution of muriatic acid of a specific gravity of 1.080. On the glass being washed and dried, it will be found as brilliant and beautiful as when it came from the hand of the manufacturer. M. Chevreul has found that the dim and dirty appearance which stained glass assumes by time is due, especially in large towns, to the various products of smoke being first condensed on the glass by fog and rain, and then becoming oxydized they act

as a cement to various mineral matters, such as chalk, gypsum, oxide of iron, &c., which help to impoverish the transparency of the glass. The alkali acts upon the organic matter and dissolves it, while the muriatic acid removes the minerals. The durability of glass placed in our monuments is extraordinary, when we bear in mind the curious results published some years since by the eminent chemist, Pelouze, who observed that when window, bottle, and other varieties of glass were reduced to a fine powder, and mixed with water, they were soon acted on, yielding a large quantity of silicate of soda to that fluid, amounting in several cases to eight or ten per cent. in cold water, and even to thirty-six per cent. when the finely pulverized glass was boiled in water; and that, in many cases, it was a definite compound which was dissolved from the glass, namely, a silicate of soda, composed of three equivalents of silica and two equivalents of soda. M. Pelouze explains the extraordinary difference in the effect which water produces on glass when in large masses of plates, as compared with its influence on the same substance when reduced into a fine state of powder, by assuming that, in the first instance, water does not act because it seldom remains sufficiently long in contact with the glass to act upon the elements which compose it; while, in the second case, there exist numerous points of contact between the fluid and the solid body, thus facilitating the action of the fluid on the solid material. I am inclined to think that the peculiar molecular condition the surface of glass assumes, when manufactured in plates or otherwise, must exercise a great influence on the property which glass has to resist the action of water. If it were not so, how could be explained the limited action which watery fields, such as wine, cause upon the interior surface of a bottle, though they remain in contact for many years? I can conceive glass assuming a peculiar surface by the pressure of the atmosphere, thereby producing a homogeneous one susceptible of resisting the action of water. A similar instance occurs in the case of polished steel, or of the rolled surface of wrought iron, or the skin of cast iron, which resist the chemical action of either air or acids in a far greater degree than does the interior of the substances which compose those metallic bodies.

Whilst dwelling upon old materials, you will allow me to give you an outline of a process devised by M. Stahl, for the preservation of antediluvian fossils. We are aware how interesting it is to preserve relics of past ages, giving us some of the conditions of the world at various periods. Those relics are exceedingly fragile, and after many clumsy attempts M. Stahl arrived at his discovery. If the fossil is compact and comparatively firm, it is saturated by means of a brush with melted spermaceti, but if it is friable, it is necessary to employ a melted mass composed of four parts of spermaceti and one of colophony resin, which in cooling gives great solidity to the mass of the fossil.

I would, in conclusion, draw the special attention of all artists who take an interest in decorative art to the interesting papers published recently by M. Onfroy on the one hand, and M. Wiel, of Paris, on

the other; the first being in the *Technologiste* of last year, the latter in the *Annales de Chimie et de Physique*, on their respective methods for covering a metal with another more valuable by its properties or precious by its qualities. These methods have a special reference to cast iron or wrought iron. In Paris, these processes, which may be regarded as not only ornamental but useful, have been applied with great success. Thus, for example, instead of the dirty, pitchy black lamp-posts which ornament our English towns, there can be seen in Paris elegant well designed bronze-like posts, which are pleasing to the eye. The same can be said of the fountains on the Boulevard Sabastopol, the Place de la Concorde, and many other public promenades in Paris, which excite the admiration of foreigners visiting that city.

(To be continued.)

On the Tenacity of some Fibrous Substances. By PROFESSOR W. J. MACQUORN RANKINE, C.E., L.L.D., &c.

Read before the Institution of Engineers in Scotland.

From the London Mechanics' Magazine, January, 1866.

In order to compare the tenacity of a substance with its heaviness, the load required to tear a given bar, strip, or cord asunder is to be multiplied by the length of so much of the same bar, strip, or cord as weighs an unit of load; the product being the tenacity of the material expressed in units of its own length. The following examples are taken from ordinary tables of the heaviness and tenacity of materials:

MATERIAL.	Dimensions.	Tearing load lbs.	Length in 1 lb. weight, in feet.	Tenacity in feet of the Material.
Cast steel bar, ...	1 in. $\times$ 1 in.	130,000	0.297	38,610
Charcoal iron wire, ...	area 1 sq. in.	100,000	0.3	30,000
Iron wire rope, ...	girth 1.27 in.	4,480	0.6	26,880
Iron bar, strong, ...	1 in. $\times$ 1 in.	60,000	0.3	18,000
Boiler plate, strong, ...	area 1 sq. in.	50,000	0.3	15,000
Teak wood, ...	1 in. $\times$ 1 in.	15,000	3.0	45,000
Deal, ...	1 in. $\times$ 1 in.	12,000	4.0	48,000
Hemp rope, hawser-laid, ...	girth 1 in.	1,050	26.0	27,300
Hemp rope, cable laid, ...	girth 10 ins.	67,200	0.279	18,750

It would be easy to multiply examples such as the preceding. If the same method be applied to the weights and tearing loads of canvas, as given in Mr. Carmichael's paper on that subject, the following are the results:

		Royal Navy Canvas.	
		Mean of Nos. 1, 2, 3, 4, 5, 6.	Mean of Nos. 7 and 8.
Tenacity of warp in lineal feet of canvas, ...	21,552		27,200
Tenacity of weft in lineal feet of canvas, ...	30,788		32,000
Mean tenacity of the flaxen yarn in lineal feet of itself, being the sum of the tenacities of the warp and weft, ...	52,340		59,200

These results show the least strength that is allowed to pass the test. Since reading Mr. Carmichael's paper, and making the foregoing calculations, I have made some experiments on the tenacity of flaxen thread and silken thread, of which the following are the results: The flaxen thread was unbleached, and measured 15,833 feet to the pound weight. Its tenacity was not uniform in different parts; and, as in the practical use of any material, the least strength alone is to be relied on, I ascertained carefully the breaking load of the weakest parts of thread, which was 6 lbs. Hence the tenacity of that thread, in feet of itself, was $15,833 \times 6 = 95,000$ feet. The silken thread was of two sizes, measuring, respectively, 9,417 feet, and 19,950 feet to the pound. The tenacity of each specimen was sensibly quite uniform at different points. The breaking load of the thicker specimen was 12 lbs.; that of the thinner specimen, 6 lbs. Hence their respective tenacities, in feet of themselves, are as follows: Thicker specimen, $9,417 \times 12 = 113,000$ feet; thinner specimen, $19,950 \times 6 = 119,700$ feet; the latter specimen thus proving to be three times stronger for its weight than cast steel.

In these experiments the length of one pound of the thread has been ascertained to the precision of about 1 per cent., and the breaking load to that of 3 or 4 per cent. It is probable that silk is the most tenacious for its weight of all known substances; and when, together with that fact, we take into account that its specific gravity is almost exactly that of water, it would seem, from a purely mechanical point of view, as if silk were the most suitable of all substances to give strength to submarine telegraph cables. But, unfortunately, when we consider the question from a financial point of view, it turns out that the price of silk is so high as to make its use in telegraph cables quite impracticable. Knowing that silk fibre is of the same heaviness with water, so that a prism a foot long, and an inch square, weighs 0.433 lb., it is easily computed that the tenacities of the two specimens in pounds on the square inch are as follows: Thicker, 49,000, very nearly; thinner, 51,900, or equal to the strongest plate.

I have also made a few experiments in order to determine the extensibility of silken thread; but the complexity of the phenomena which take place when that material is stretched have hitherto prevented my obtaining precise results. Even a small load produces a stretching which gradually increases with time, and which also gradually disappears after the load has been taken off. A load of $5\frac{1}{2}$ lbs. put upon a thread of the thicker kind, whose original length was 52.78 inches, produced a total extension of 3.56 inches, of which between 1.5 inch and 1.6 inch was *set*, continuing when the load was taken off, but gradually diminishing afterwards; while the remaining inch, or thereabouts, was elastic strain. About half of the set, viz: .75 or .8, had disappeared two hours after the load was taken off; the remainder continued to exist after the load had been off eight hours. The extension, with a given load, was on an average about 0.10 inch less when the load was increasing than when it was diminishing, showing the effect of what Professor William Thomson has called "molecular

friction." The results of the experiments correspond, on the whole, approximately with the following value: Modulus of elasticity of silk fibre, 3,000,000 feet = 1,300,000 lbs. on the square inch. If we take the proof load, or greatest safe load, at one-third of the breaking load, the modulus of resilience or power of bearing shocks, which is a third proportional to the modulus of elasticity and the proof strength, is found to be as follows, for the thicker specimens of silken thread: 473 feet, (that is, 473 foot-pounds for a prism weighing 2 lbs.,) corresponding to 205 foot-pounds for a prism 2 feet $\times$ 1 inch $\times$ 1 inch. The resilience of a tie-bar 2 feet long, and 1 inch square, has the following values for some other substances: Very strong tough steel, 60 foot-pounds; strong hard steel, 46; soft steel, 31; good iron wire, 36; good bar iron, 14; strong plate iron, 12; strong tough cast iron, 4. Occasions may arise when it is necessary to have cordage of the least possible weight for a given strength or for a given resilience, without regard to expense; and then, without doubt, the best material is silk.

The Cohesive Force of Red Sealing Wax.

From the London Mechanics' Magazine, January, 1866.

The cohesive force of the best red sealing wax has been proved to be equal to 1500 lbs. per square inch, and that of the black sealing wax rather more than 1000 lbs. to the square inch; the deficiency in the latter is attributed to the diminished quantity of lac used in the composition. The cohesive force of solid glue was found to be 4000 lbs. per square inch, that of cast iron is 25,000 lbs.

On the Properties of Parkesine, and its Application to the Arts and Manufactures. By ALEX. PARKES, Esq., of Birmingham.

From the London Journal of the Society of Arts, No. 683.

In introducing to this meeting the subject of Parkesine, the author wishes to explain the reasons that led him to the production of this substance.

For more than twenty years the author entertained the idea that a new material might be introduced into the arts and manufactures, and, in fact, was much required; he succeeded in producing a substance partaking, in a large degree, of the properties of ivory, tortoise-shell, horn, hard wood, india rubber, gutta percha, &c., and which will, he believes, to a considerable extent, replace such materials, being capable of being worked with the same facility as metals and wood. This material was first introduced under the name of parkesine, (so called after its inventor,) in the Exhibition of 1862, in its rough state, and manufactured into a variety of articles in general use; it then excited the greatest attention, and received a prize medal, Class IV., 1112.

Parkesine is made from pyroxyline and oil, alone or in combination

with other substances; the various degrees of hardness or flexibility are obtained in the easiest and most expeditious manner by varying the proportions of pyroxyline, oil, and other ingredients.

The pyroxyline, used as the base in the manufacture, can be made from any vegetable fibre, or fibre-producing grasses, starch, &c., but preferably of waste from cotton and flax mills, old rags, paper makers' half stuff, or any fibrous waste material capable of being reduced into a soluble condition by the action of acids. To subdue the inflammable nature of this compound, the inventor has introduced several substances, such as iodide of cadmium, tungstate of soda, gelatine, chloride of zinc, several carbonates, sulphates, phosphates, and other substances.

The oils employed are some of the vegetable and some of the animal kingdom; they may be used alone or combined, either in their normal condition, or changed by a solidifying agent, chloride of sulphur being preferred, which has the remarkable property of completely solidifying the oils almost instantaneously; but the chemical combination can be modified according to the per centages of the chloride of sulphur employed, which may be varied to meet the exigencies of commerce. These solidified oils, although unchanged by ordinary reagents, are readily soluble in the author's solvents of pyroxyline, by which means the two ingredients are combined to form one of the descriptions of parkesine.

The inventor, after much research, labor, and investigation, observed that the solid residue left on the evaporation of the solvent of photographic collodion produced a hard, horny, elastic, and water-proof substance. This led him to employ, in all his experiments, pyroxyline, xyloidin, or some collateral matter, as his base for future operations. By the word pyroxyline, the author wishes to be understood a less explosive preparation than the more highly converted compound "gun cotton," and his constant aim has been to apply to peaceful industrial purposes a material hitherto only used for military, blasting, and photographic purposes. The solutions of collodion known at the time of his first patent, in October, 1855, were practically unsuited to carry out the manufacture in solid masses and other large forms. This necessitated a new series of experiments, to discover a more economical mode of production, and he found that, by improving the manufacture of pyroxyline, and using different solvents, considerable success was attained. As an illustration, to show the impracticability of using collodion for the manufacture of solid articles, we have here a bottle of ordinary collodion, which is submitted to your notice. This is a solution of pyroxyline in the well known solvents, ether and alcohol, and when you are told that, in one pint of these mixed solvents there is only one-third of an ounce of solid material, and the whole of this pint of solvents must be evaporated to obtain this small quantity of hard substance, you will readily conceive that the cost of production would be much too high for large commercial purposes. The cost of 1 lb. of the mixed solvents would be 2s. 6d., the pyroxyline being 10s. per pound, and as 1 lb. of pyroxyline would require 48 lbs. of solvent to make photographic collodion, there will be a total cost of 130s. per

pound for the solid material which could be obtained from the evaporation of such solvents. The small specimen of pyroxyline now exhibited is the exact weight of that contained in the bottle, whereas, by employing the same quantity of the author's patented solvents, this large bulk of unconverted cotton, which, for the sake of safety, represents a similar bulk of pyroxyline, can be dissolved sufficiently for the manufacture of parkesine.

The author commenced his investigations in face of the above-named difficulties, and endeavored, by more economical methods of manufacturing the pyroxyline or other similar compounds, and by the use of improved and less costly solvents, to produce a new and cheap material. This, after many years of labor and thousands of experimental trials, he has succeeded in doing, and at the present time almost any quantity may be made per day, (many tons—simply depending upon the apparatus,) at a cost of less than 1s. per pound and upwards, according to the quality required.

The two specimens shown illustrate the great difference between the two productions. The small piece is made from the collodion of commerce, at a cost of 130s. per pound; and the sheet is the result of that made from the present mode of manufacture, at a cost of less than 1s. per pound. This will at once establish in your minds the practical value of the invention.

Having then satisfied himself as to the possibility of producing the material at such a price as would allow of its application in the arts, his next step was, by the combination of various substances, to counteract the inflammability of the material—to produce various colors—and to modify its hardness, toughness, and elasticity; and, although from the above statements the object sought to be obtained may appear exceedingly simple, it nevertheless necessitated an enormous amount of application to arrive at the knowledge which has enabled him to produce the specimens which are now laid before you.

One of the greatest difficulties in the earlier stage of his experiments was caused by the excessive contractile properties of the dissolved pyroxyline, as the piece now produced, as compared with the comparatively large bottle, will clearly exemplify, being the whole of the solid residue contained in 35 cubic inches of collodion; in fact, if a stiff solution of pyroxyline were made, such as would not flow from a bottle, still such a preparation would contract to from ten to fifteen times its volume, whilst in the present workings only from one-fourth to one-fifth of a pound of solvent is used to one pound of pyroxyline; consequently the contraction is reduced in proportion to the solvents used.

The author had long to contend against the adverse opinions of many, that his efforts to introduce such an article for the general purposes of manufacture, from such expensive materials, appeared hopeless; and even since specimens were shown at the Exhibition of 1862, much discouragement has been thrown in the way of the progress of the invention by many who had conceived the idea that it would be impossible to produce the material at a price that would render it

valuable for general application ; the inventor feels proud that he has been enabled to surmount these obstacles in so far establishing a new manufacture which—by the intelligence of practical minds, which he trusts will be devoted to its further development—will, he ventures to hope, eventually become one of considerable commercial importance.

The innumerable trials and investigations required, involved no less than twelve years labor and expenditure of many thousand pounds, before the material could be proved to be really of commercial importance ; and although this may appear a long time to pursue one object, the author wishes to explain that time itself has been of the utmost importance in developing this manufacture, as it has enabled him to test the effect of time on the material, and also of atmospheric changes, and many other influences ; this has proved of great value in arriving at his present knowledge of the material. Although he has been much engaged in other important business he was determined not to relinquish the manufacture of parkesine until the truth of what he stated at the Exhibition, in 1862—that the material could be produced in some of its qualities at 1s. per pound—was proved, and this he has satisfactorily established by twelve months practical working. One of the means which enabled him to produce parkesine at a cheap rate, is the employment of waste cotton, in the shape of rags or otherwise, which are procurable at an exceedingly low price, and also the use of improved solvents, and the means of recovering them by special machinery ; also the being able to dissolve the pyroxyline in a wet state, thus avoiding the time and great space and risk of drying, which was the practice until recent important improvements enabled him to accomplish this most important desideratum.

When it is necessary or desirable to increase the flexibility or elasticity of preparations of pyroxyline, the author combines therewith oil, solidified or partly solidified by the action of chloride of sulphur, a reaction discovered by him some twenty years ago, when engaged in investigations relative to the cold process of vulcanizing india rubber, patented by him about that time. The chloride of sulphur is dissolved into bisulphide of carbon or mineral naphtha, the proportion suitable for the purpose being from 10 to 15 per cent. of chloride of sulphur to the cotton-seed, castor, or other oils. This will be found (as will be exhibited to you by experiment) to be of a solid or semi-solid consistence, according as more or less of the chloride of sulphur is used, so that the physical condition of preparations of pyroxyline may be considerably modified to suit special application by the use of gums, resins, paraffin, stearine, tar, glycerine, and other substances combined therewith.

The author would observe that the result of using a large proportion of the chloride of sulphur is to solidify the oil, (even to a jet-like mass,) but it is preferable to use about 15 per cent. to produce a tough elastic substance. He wishes it to be observed, generally, that in proportion as the oils predominate, so is the elasticity of the materials regulated.

Another important improvement in the manufacture of parkesine

is the employment of camphor, which exercises an advantageous influence on the dissolved pyroxyline, and renders it possible to make sheets, &c., with greater facility and more uniform texture, as it controls the contractile properties of the dissolved pyroxyline; camphor is used in varying proportions according to requirement, from 2 per cent. to 20 per cent. Another of the author's improvements for the like object consists in the use of gelatine dissolved in glacial acetic acid.

The author believes he was the first to employ colors in the dissolved pyroxyline. The solvents used in the manufacture of parkesine are also good solvents of the aniline colors; this gives the great advantage of producing the most beautiful colors in a transparent substance, as well as in opaque or solid masses, as the specimens will show; and when these colored articles are carved, the most exquisite effects are produced, imitating amber, malachite, and many other natural substances; moreover, as the material can be moulded by pressure, the most beautiful works of art can be copied at a very small cost. For many large and cheap applications, as much as 60 per cent. of pigments, sawdust, or cork-dust can be introduced with advantage, and thus is produced a beautiful and solid substance, very strong, which can be moulded and turned in a lathe or rolled into sheets, the cost, owing to these admixtures, being exceedingly low.

In all large manufactures the most important point to be considered is the production of raw material, which, in many cases, fails in quality and supply. The substances the author employs in the manufacture of parkesine are procurable in any quantity, and having a perfect control in the manipulation of the materials used, he can always ensure a regularity in the various qualities required, thus placing at the command of the artisan a material to be had at all times of a uniform standard quality, which he conceives to be no slight boon to the manufacturer.

There is another important feature in the economy of this material—no loss in manufacture is experienced, every particle, scrap, or dust can be reworked, and the most beautiful effect produced. Specimens will show the effect of some of the waste scraps remanufactured, and it will be readily seen that by careful admixture of colors very pleasing results may be obtained. This is another important advantage over other materials, such as ivory, tortoise-shell, india rubber, vulcanite, gutta percha, &c., with which this substance is calculated to compete.

The difficulties in manufacturing this material on a commercial scale were at first very great, as before explained, but by steadily persevering, the manufacture is now rendered very simple and rapid. From five to ten tons of parkesine sheets can now be produced in less time than one ton of india rubber. Sheets of large size and of any thickness, solid blocks, tubing, or other forms, can be made in a few minutes, and from the cheapness and unlimited supply of the raw materials employed, the price of parkesine will, it is believed, be much less than that of india rubber, ebonite, gutta percha, ivory, tortoise-shell, and many other materials.

Many specimens on the table have been produced from materials made ten years ago, in which no change or decomposition has taken place; the substance is not affected by sea-water, in which it has been immersed for a period of four years without the least deterioration, nor is it softened by heat like gutta percha, and, therefore, it is not likely to be affected by the heat of tropical climates.

It can be made transparent, or in any colors, variegated to imitate tortoise-shell, marble, malachite, hard or flexible; can be moulded, shaped, by dies or pressure, turned in a lathe, worked into screws, cut with a saw, planed, carved, engraved, rolled or pressed into sheets, as all the articles in the case before you will clearly show; it is very agreeable to the touch, and is susceptible of the highest polish; it can be inlaid with metals without any injurious effect upon them after years of exposure; it is also invaluable as a water-proofing agent, and can be used as a varnish for a variety of purposes, and as a non-oxidizing agent for the protection of iron ships, &c.

The various stages of manufacture are fully illustrated by the variety of specimens now before you, from the unprepared cotton waste to the ultimate conversion into the finished articles.

Perhaps one of the most interesting facts in connexion with this new manufacture is the employment of nitro-benzole, or aniline, by which improvement very great facilities are obtained in dissolving pyroxyline, and as these materials are also solvents of india rubber and gutta percha, a combination of these substances may be readily obtained which will be valuable for many purposes. A specimen of this combination is on the table.

The applications of this material to manufactures appear almost unlimited, for it will be available for spinners' rolls and bosses, for pressing rolls in dyeing and printing works, embossing rolls, knife handles, combs, brush backs, shoe soles, floor-cloth, whips, walking sticks, umbrella and parasol handles, buttons, brooches, buckles, pierced and inlaid work, book-binding, tubes, chemical taps and pipes, photographic baths, battery cells, philosophical instruments, water-proof fabrics, sheets, and other articles for surgical purposes, and for works of art in general.

There is one application of the parkesine which, as far as experiments have gone, promises to be of great importance, viz: insulating telegraph wires. It will be at once evident, from the nature of the ingredients used, that by simple mechanical and chemical processes, perfect freedom from impurities or foreign ingredients can be attained—a most important property in a material which it is intended to employ for electrical and insulating purposes. The difficulty of producing a pure and homogeneous article, has, there is reason to believe, resulted in the total failure of some thousands of miles of submarine cables and underground wires. Parkesine is placed upon the wire by being forced through a die in successive coatings with the same facility as gutta percha, and the author believes it to be far less liable to faults than india rubber.

A few specimens of the application of the material for electrical and

telegraphic purposes are exhibited. It is, however, deemed advisable to state, that extensive experiments have been made under the direction of Mr. Owen Rowland, (electrician to the late Joint Committee of the Board of Trade and the Atlantic Telegraph Company, appointed to inquire into the construction of submarine telegraph cables, &c.,) with the view of ascertaining to the fullest extent the electrical properties and applicability of the material for the above important purposes. The results of these experiments leave no reason to doubt that, on the completion of the necessary machinery, a most excellent and efficient insulator will be produced, (and, indeed, it has already been produced, even by imperfect and inadequate machinery,) possessing all the requirements of insulation.

Short specimens of insulated wire (made by hand) in this substance for underground and ariel lines are exhibited, the latter in the form of a multiple cable, according to the valuable patent of Professor Wheatstone, containing an insulated sustaining iron wire, and seventy-nine insulated conducting copper wires, both insulation and protecting envelope being effected by parkesine, which, possessing great strength and flexibility, and being a non-oxidizing material, is extremely well adapted for the latter purpose. This cable is believed to be capable of bearing its own weight in air for a distance of upwards of one mile.

In its hard and solid form, by virtue of its high insulating and non-oxidizing properties, this material is peculiarly well adapted for electrical instruments, terminal boards, testing boxes, batteries, insulators for poles, and many other philosophical purposes, and the advantages to be derived from the employment of a material which remains free from oxidation under all conditions, will be duly appreciated by electricians and experimentalists in their daily operations and investigations. Its tensile strength is considerably above that of either gutta percha, india rubber, or any other insulating material. Joints can be made with the greatest facility and perfection.

In the following instruments on the insulating power of parkesine as compared with various other materials, the greatest care was taken to secure a correct and reliable result. The temperature was constantly maintained at 61° ; the pieces were thoroughly dried, to avoid surface conduction; the same surface length of each made to rest on the metallic stand in contact with earth; the blotting paper between the *piece* and the metal kept saturated with water, so as to ensure complete surface contact; the leakage of the instrument itself frequently ascertained; the full tension at the commencement of each test recorded as well as the exact time. The tests, in some instances, were repeated several times with uniform results.

Experiments made at Hackney Wick, on the 29th August, 1865, on the loss of insulation on the lengths of variously coated copper wires, &c.; instrument employed, a Peltier electrometer. Full tension, 40; temperature, 61° Fahr.

Parkesine, ...	5° in 1' 45''
Plain gutta percha, ...	5° " 0' 37''
Gutta percha and Chatterton's compound, ...	5° " 1' 8''
Plain gutta percha covered with parkesine, ...	5° " 1' 4''
India rubber, (masticated,)	5° " 1' 15''
India rubber, (virgin,)	5° " 0' 30''
Ebonite disk, ...	5° " 2' 10''
Parkesine disk, ...	5° " 2' 35''

The author has been furnished by Mr. Owen Rowland with the result of a further series of experiments made recently by him on the insulating properties of the material. These tests were made upon slabs and sheets of various qualities, hardness, and flexibility. Specimens are exhibited.

The value of the insulating properties of each piece in comparison with ebonite is shown in the following table:

No. 1 specimen,		Leakage.	Time.
" 2 "		11·5° in	1080''
" 3 "		11·5° "	510''
" 4 "		11·5° "	180''
" 5 "		11·5° "	360''
" 6 "		11·5° "	210''
" 7 "		11·5° "	185''
" 8 "		11·5° "	212''
" 9 "		11·5° "	509''
" 10 "		11·5° "	25''
" 11 { Prepared oil or base of Parkesine. }		11·5° "	2046''
" 12 Ebonite,		11·5° "	1930''
			1050''

The third column shows the time occupied by the needle of the electrometer in falling from the maximum tension of the electric charge to one-half tension thereof, or from 50° to 38·5°.

It is satisfactorily proved that the more perfect the means adopted for rendering the material free from impurities, the more its efficiency for insulating purposes increases.

(To be continued.)

On the Flow through Apertures of Solid Bodies.

From the London Practical Mechanic's Journal, February, 1866.

In the preceding number of this Journal a review was given of the part for July, 1865, of the *Annales du Conservatoire Imperial des Arts et Métiers*, in which prominence was chiefly assigned to a memoir by M. Tresca on "The Flow (*écoulement*) through Apertures of Solid Bodies." These experimental investigations have done science so important a benefit by demonstrating as laws what have hitherto been more or less hypothetical, that the writer has deemed it expedient to place on record, in English technical literature, a *résumé* of the principal experiments upon which the conclusions hereafter given are based.

The memoir was presented to the Academy of Sciences on the 7th of November, during its session of 1864. It originally contained the first part of the investigations by M. Tresca on the flow of solid bodies, and which were completed June 12, 1865, being the subject matter of a report by General Morin in the name of a commission composed of MM. Pouillet, Piobert, Duhamel, and Morin—the first investigations being immediately followed by fresh researches on the same subject.

The memoir presented to the Academy has the following for its objects:

1. To show by the results of numerous experiments that solid bodies, when a pressure sufficiently intense is exerted upon them, flow in a manner similar to that of liquids. 2. To lay down the theory of this flow, and to point out the most important deductions that may be made to facilitate the study of the molecular motions, which are produced by the action of mechanical force on matter.

The same phenomena are proved for the soft as for the hard metals, for plastic substances, such as blocks of wax, for pulverulent matter, for granulated materials, such as musket shot, and in a manner only less complete than that for liquids themselves.

The newly discovered analogy which is found to hold alike in all bodies, in their varied conditions, has enabled some light to be thrown on the principles of the flow of liquids, as well as upon their *lateral attraction*, which these experiments on the flow of solid bodies determine, under a variety of circumstances.

This investigation has not been undertaken as a sequel to preconceived ideas, and as a point that it had been proposed ultimately to reach; neither is it presented as the mere consequence of varied experiments obtained in the first place among complex circumstances, so as to render many observations liable to be recalled as erroneous, but such that the laws of the phenomena themselves can be studied with facility.

Of the numerous experiments that have been made, the writer limits himself to mention three, which suffice to make known their character, and these he regards as fundamental. An example of each kind forms the head of each of the following citations of the experiments.

It is not desired to at once decide these as general consequences, without again returning to the inquiry concerning the flow of solid bodies, and a future opportunity is therefore reserved to review the circumstances in detail, and to examine the numerical data to be derived.

One of the experiments relates to the punching of metals; the second to the crushing of a cylinder composed of superimposed plates; the third to the simultaneous flow of a cylindric block of metal over its lateral surface and through a central orifice. It is, therefore, seen from the preceding statements, that there are three distinct types of experiments bearing, in their different aspects, upon the transmission of pressure into or through solid bodies, so as to ascertain whether the pressure does not reach beyond intermediate portions.

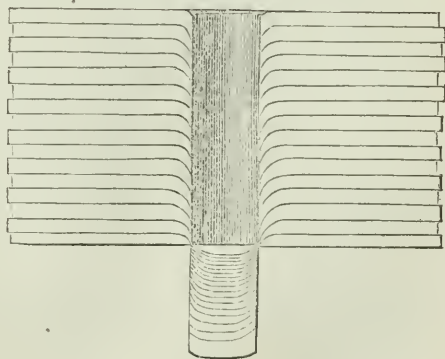
Experiment made on the 22d of April, 1864, upon the punching of a rectangular block composed of sixteen plates of lead.—The plates were square and $0^m.120 = 4.727$ inches in length of sides, the thickness being 4 millimetres = $.1572$ inch, and the total thickness of the block of plates was $0^m.064 = 2.5198$ inches.

The plates were carefully placed one upon the other between two holding or guide plates, each of which was pierced with a hole in it of 20 millimetres = $.7860$ inch diameter, and fitted with a punch sufficiently long to pass completely through the guide plates and blocks. The force of an hydrostatic press being applied to the extremity of the punch, this penetrated the lead block, the metal of which moved away (*chassé*) before the punch in the form of a cylinder of 20 millimetres = $.7860$ inch diameter; but this extended cylinder had only a height or length of 31 millimetres = 1.129 inch, whilst the total depth of the hole was the total thickness of the series of superposed plates, viz: 2.5198 inches. (I must here premise, that in future in this memoir, I shall use the French term “*débouchure*” to express the portion or mass of metal that is punched out or extruded from the block under experiment, as there appears to be no word in the English language which so decidedly expresses the meaning which, in the present case, it is desired to convey. It is true we have the word “burr,” a workshop term for the piece of metal punched from a plate, and even this, irregular and non-etymological as it must be from its origin, answering the purpose of the operative boiler-smith, is wholly unsuited for the present purpose.) This diminution of height had been before obtained in the punching of a solid block of lead of the same dimensions as the laminated block.

Accordingly, the *débouchure*, which should have been 64 millimetres = 2.5198 inches in height or depth, was in reality but 31 millimetres = 1.130 inch; the density of the metal not having, as might have been supposed, increased during the process of punching, the experiment tried with superposed plates ought, therefore, to decide the question of knowing how the elimination of half of the metal, which occupied beforehand the place filled so slowly by the punch, was produced.

This *débouchure* of the 22d April, Fig. 1, is indeed remarkable. On cutting it in half, and facing or smoothing over the cut faces, the fifteen lines showing the number of divisions of the primitive block were visible; but whilst the topmost plate and the three lowest plates *only* were represented in the débou-

Fig. 1.



chure in their original thickness, all the intermediate plates were represented with their original thickness considerably reduced, as will be seen by reference to the following table of measures taken on dividing off or separating the lower faces.

The elimination of the metal, then, took place horizontally throughout the intermediate parts of the block proper; then, without doubt, the resistance in that direction was less than that of all the layers or strata situated in front of the punch.

TABLE of the Thicknesses of Plates Measured along the Axis of the Débouchure.

Number of Plates in the Débouchure.	Distances of the Lines of Joints to Extremity of Débouchure.		Thicknesses of Plates Measured along the Longitudinal Axis.	
	Millimetres.	Inches.	Millimetres.	Inches.
1	4.6	.1807	4.6	.1807
2	9.0	.3587	4.4	.1729
3	13.0	.5109	4.0	.1572
4	16.2	.6366	3.2	.1257
5	20.0	.7860	2.8	.110
6	20.8	.81764	1.8	.0708
7	22.0	.8616	1.2	.0471
8	22.7	.88911	0.7	.0275
9	23.4	.92962	0.7	.0275
10	23.9	.9347	0.5	.0196
11	24.2	.952	0.3	.0117
12	24.6	.967	0.4	.0157
13	24.8	.975	0.2	.0078
14	25.3	.995	0.5	.0198
15	26.9	1.057	1.6	.0628
16	31.3	1.230	4.4	.1729

The first consequence to be drawn from the foregoing is, that the vertical pressure exercised by the punch transmits itself laterally or horizontally through the solid block, and repels the material of the débouchure into it in the direction of least resistance.

But this observation, which is certainly one of the general results of actual work, is not the only one which can be drawn; there is found, besides, that distinctness of the concentricity of the couches or strata that are met with among circumstances more simple and better defined.

The lines of joint are slightly curved in that portion contiguous to the axis of the débouchure; and on carefully examining them by aid of a microscope, it is found that they touch the extreme diameter of the portion of the débouchure immediately above, each one of the portions of the plates thus forming a kind of capsule with very thin edges, enveloping on all sides those capsules situated immediately above it, whilst it itself is similarly enveloped by the capsules situated below in the order of primitive superposition.

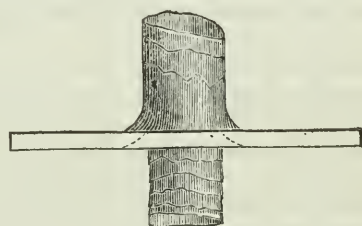
This disposition of the strata in the débouchure has elsewhere its analogue in the pierced block.

Each one of the plates traversed through by the punch bends itself or yields in a curved form around the hole formed by the passage of the tool, being tapered off very fine at the parts bordering on the hole in such a manner as to be drawn out in an extremely thin tube, and so that a perfect division or lining is uniformly produced all through the punched hole by the tube primarily issuing from the superior or uppermost plate; which tube is successively caught into the substance of the next plate by the other tubes proceeding from it; and thus throughout the blocks the tubes, respectively, forming the elongations of each one of the primitive plates.

The plates, being imbedded one in the other, cannot be separated without fracture. Moreover, the same disposition of their fractures facilitates the verification of the summary indications about to be given.

The annexed Fig. 2 is given with the fractured or separated tubes which accompany it, and which belong, that is to say, which are broken off on the upper sides from plates 3 to 5, and on the under from plates 7 to 13, in the order that they occur in the block, the upper parts of these fractured tubes remaining adhering to the different plates.

On cutting through similar blocks, the cut being across the axis, there is also found all the lines of joint, and the tubular constitution appears with the completest evidence; also, that these (tubes) are preserved by the pressures transmitted by the adjoining strata, (*couches*.)



Each one of the plates appears endowed with more perfect malleability, which permits it to laminate to the extremest thickness without being torn or fractured. This valuable property will be observed in nearly all the examples that will be cited.

Since then, there has been found in the débouchures of thick iron plates produced in the workshops of mechanical engineers the same lateral elimination and the same capsules.

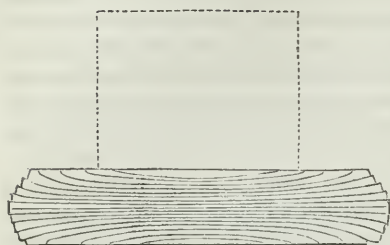
The first observations on the punching of lead are found, moreover, verified for a hard metal, such as iron, punched cold.

Experiment of June 3, 1864, on the crushing of a cylindric block made up of twenty plates of lead.—These twenty plates had together a thickness of $0^m.063 = 2.48$ inches, and a common diameter of $0^m.060 = 2.36$ inches.

This diameter had been produced to $0^m.110 = 4.39$ inches, by crushing, at the centre of the height, and to $0^m.103 = 4.05$ inches, and $0^m.105 = 4.134$ inches at the ends, the original height being thus

found reduced to $0^m \cdot 108 = 4 \cdot 253$ inches. All the plates are not found

Fig. 3.



to comport themselves in the same manner. The end (that is, the top and bottom plates, Fig. 3.,) are scarcely increased in diameter, whilst the edges of the intermediate plates are bent up all round, in a manner as to form with them the flat upper and lower faces of the crushed or compressed block.

The thin or shallow block (*gallette*) thus formed being cut across the axis, it is found that the deformations were not identical for

all the blocks. On the contrary, it was seen that the deformation was produced especially at the centre of the block, a flow from the axis to the circumference having taken place; and the lines of joint, which were at first parallel, formed by the compression a sort of saucer, very thin and spread out at the centre, and growing thicker towards the edges, which shows in what direction the displacement of the molecules took place.

Poncélet had long since pointed out how, resulting from the resistance due to friction, the expansion or thinning out of the base of a cylinder was prevented, in an investigation upon the more marked thinning or compression (*épanouissement*) which was produced in the central portions; but this retardation is in reality much greater than the exterior appearance would give reason to suppose, since the experiment actually shows that the original vertical wall (*paroi*) becomes folded into the plane of the base in a manner to increase the diameter of the primitive or original base. The lines of joints of the upper and lower plates after compression become curved to extreme edges, and the parts which were formerly vertical edges are now thinned out, and, as it were, run or flow into the planes of the upper side and base of the crushed cylinder. Thus each of the planes of the original joints is transformed alternately into a convex and concave surface.

This experiment is especially cited because the result produced justifies, in a prominent manner, the rather strange expression employed when speaking of the *flow of solids*, (*l'écoulement des solides*.)

This block of twenty plates had been compressed between two blocks of metal. One of these pieces was of cast iron, dressed by a file; and the impression (*thinning*) is apparent on the surface of contact of that piece, following the concentric couched disposition previously indicated. The other supporting piece was of malleable iron plate surfaced in a planing machine, the striated tool-marks being allowed to remain on it.

These striae, all of which were parallel, formed so many little canals, which were almost microscopically small—three such canals, with their divisional boundaries or ridges, being equal to a millimetre in breadth over all. They sufficed, however, to considerably facilitate the flow of

the crushed metal; moreover, the lines of joints, as they became successively impressed upon that surface, spread out in an *oval* in place of a *circle*, their normal form; and the circles of the *original* vertical wall of the cylinder, now having flowed over parallel to the surfaces of compression, these also become converted into oval forms, the major axis of which is situated parallel to the direction of the little canals. This last fact has been reproduced in a great number of experiments, and should be enough to distinctly indicate the marked fluidity of solid bodies when acted upon by great pressures.

Experiment of August 24, 1864, on the simultaneous flow, at the edge and at the centre of a block formed of two plates of lead.—Two plates, 3 millimetres = $\cdot 1179$ inch in thickness, and 100 millimetres = 3.93 inches in diameter, were placed under a hammer. They rested upon a plate pierced at the centre by an orifice 20 millimetres = $\cdot 7860$ inch in diameter, and there was placed upon the upper surface of the second plate a steel cylinder of 50 millimetres = 1.965 inch in diameter; which cylinder was formed with a sharp point at the centre of its upper end, so that when struck by the hammer the force of the blow might be evenly imparted to the whole of the surface of the plate immediately below the cylinder.

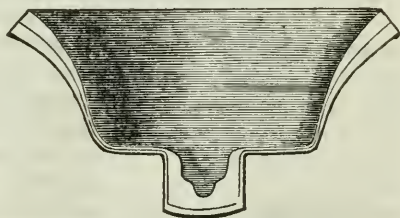
The compression having been determined by ten successive blows of the hammer, the different pieces were lifted off, and it was found that the original thickness of the plates had been reduced to 2 millimetres = $\cdot 0786$ inch, over the whole part comprised between the two faces of the pieces of metal over which the pressure had taken place. Throughout the whole of these parts of the plates, the two faces (upper and lower) remained flat, as well as the surface of the joint; but beyond this and at the centre the plates had undergone very considerable and remarkable modifications.

At the exterior (see Fig. 4) the plates became curved upwards in the form of a widely open tulip, their thickness gradually thinning down, as if the stream of matter that the force of the blows had extruded had, at the same instant, a thickness determined by that of the part compressed, the two thicknesses being found the same.

This very regular tulip-shaped cup of lead recalls, but under more distinct conditions, the beautiful acanthus-shaped leaves obtained by MM. Piobert, Morin, and Didion in their experiments on the stroke of leaden projectiles.

It is possible to determine the exact nature of the surfaces thus transformed, but it will suffice at present to assert that the transformation results geometrically from the gradual flow of metal of the cylindric ring comprised between the two points which exert the compression, as well as from the resistance that the ring thus extruded at

Fig. 4.



the same instant experiences, in consequence of its connexion with the neighboring molecules at once introduced into the thinned part of the plate.

At the centre the modifications are of the same order.

The portions of the plate squeezed through the central hole in the lower plate form a sort of hollow jet, (*débouchure*,) thick at the centre; and from this point the walls of the hollow *débouchure* diminish in thickness, in a manner similar to what has previously been shown for the outer extruded portions of the plates. The central flow of the metal would appear to have drawn together the middle parts of the plates, and to have transported them to the extremity of the jet.

This example proves very clearly that the vertical pressure between the two supports (upper and lower) is transmitted through the leaden block to the free parts at the centre opening of the bottom plate, and at the circumference of the two plates between which the pressure is exerted, and that this action has produced two jets or flowings of metal of different forms, but both possessing one common property—that the thickness of the walls in each case successively or gradually diminishes, and the original plane surfaces become changed into those of a curved form, approaching more or less the form of a cylinder, and representing the result of the two contrary actions; one of these depending on the fact of transmitted pressure, the other on the bending or cohesion of the particles of the material.

This circumstance, which appears paradoxical, it is difficult to otherwise explain, from the void or empty space in the central jet occurring precisely at the single point where the pressure which should be transmitted to the mass of lead is not counterbalanced by the resistance of an interior support. It is believed that the jet, in place of being cylindrical at the exterior, becomes contracted, so that the original thickness of the plates becomes much reduced. From this one analogy with the flow of liquids, it enables an analysis to be made of the principles which determine for all bodies the contraction (*vena contracta*) so long since observed in the flow of liquids.

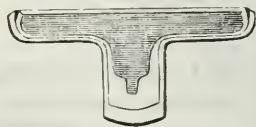
The experiment which will presently be described, considered in its entirety, realizes the double flow which was simultaneously obtained through an orifice at the centre as well as one at the exterior.

It was made much more quickly, as the pressure was produced by means of an hydraulic press; but in order

to vary as much as possible the mechanical elements of the question, it was thought preferable in this, the third list of experiments, to attract attention to one of the samples of material experimented upon, in which the compression and consequent flow was produced by means of hammer blows:

both the experiment with the press and with the hammer furnished analogous results.

The influence of the ring or boundary outside the plates is completely shown in the sample experimented upon on the 20th August, 1864. See Fig. 5.



(To be continued.)

A New Process for Quickly and Economically Converting any Mass of Cast Iron into Steel. By M. GALY-CAZALAT.

From the London Chemical News, No. 320.

The author passes superheated steam into the fused iron. In traversing the mass the steam is, of course, decomposed; the oxygen burns progressively the carbon and oxide of iron, while the hydrogen combines with and removes the sulphur, phosphorus, and other metal-loids which render the steel brittle. When the color of flame at the top of the mass indicates a proper amount of decarburation the steel is run out. The author operates either in a cupola or a reverberatory furnace of his own construction, in which the waste heat from the furnace is utilized to produce the steam. There has always been a difficulty in knowing when to stop the decarburating current, the process often being carried too far; but to-day, says the author, common steel can always be regularly produced by completely decarburating the cast iron and then adding 10 per cent. of spathic cast iron, which restores to the iron the amount of carbon necessary to effect the conversion into steel. By a peculiar contrivance the author shuts off the current of superheated steam from the metal and passes it into the chimney, where it serves to increase the draft in the furnace, and thus leaves the steel in a state of tranquil fusion for about fifteen minutes, by which he gets a perfectly homogeneous mass. To remove bubbles in his castings he has a very ingenious device. A cannon, for example, being cast, while the metal is still hot and soft, he covers the mould hermetically with a sort of hat, from the top of which rises a pipe, in which is placed 6 or 10 grammes of a mixture 80 parts of saltpetre and 20 parts of charcoal. By opening a stop-cock the powder is allowed to fall on the metal, where it gets ignited, producing a large quantity of gas which exerts pressure on all parts of the casting, removing the bubbles and increasing the tenacity of the metal.

New Differential Anemometer. By E. SWANN, F.C.S.

From the London Chemical News, No. 322.

I beg to forward, for insertion in the *Chemical News*, a description of an instrument for measuring slight variations of pressure, trusting that the information may be of interest to many of your readers, not only on account of its practical value, but also as an ingenious application of a philosophical principle.

The instrument in question is in use at the London and North Western Works at Crewe, and is the invention of Mr. Ramsbottom, the company's mechanical engineer.

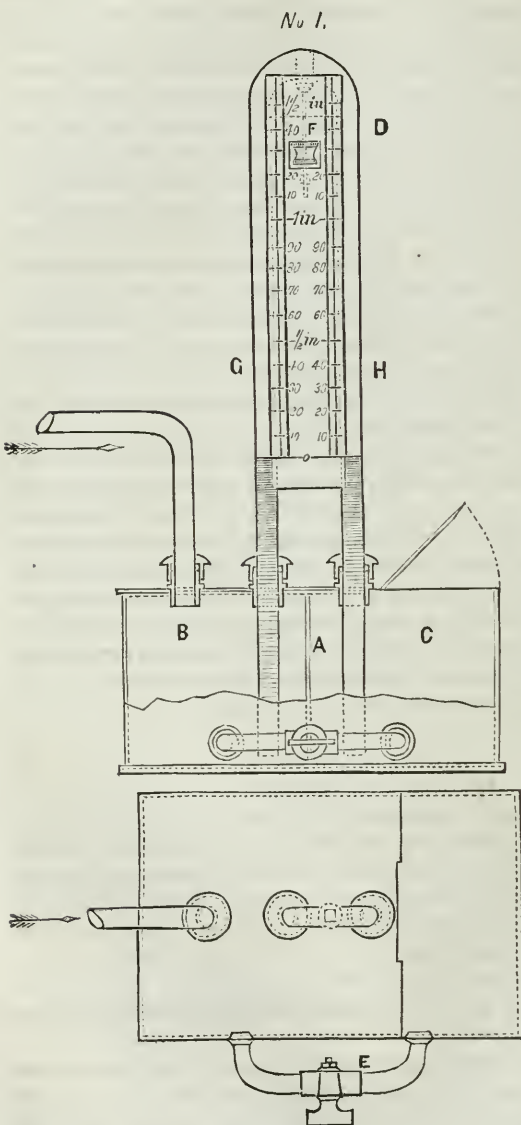
At these works Siemen's system of gas furnaces is being introduced for the manufacture of iron and steel, and as it has been found advisable to register the pressure of the gas, which only varies a few hundredths of an inch of water, an instrument of more than ordinary delicacy was required.

It occurred to Mr. Ramsbottom that an instrument having the requisite sensitiveness might be constructed on the differential principle

by means of a syphon tube, containing two fluids of different densities. As shown by the accompanying diagram, the instrument consists of an oblong box, divided, by the diaphragm (A), into two cisterns, one

of which (B) is air-tight and fitted with a tube through which the pressure is applied, and the other (C) merely closed by a lid. The two cisterns are about half filled with water, and are connected by means of a glass syphon tube, the legs of which are equal in length. The ends of the tube pass through glands, and reach nearly to the bottom of the cisterns.

The upper half of the tube is filled with a fluid, such as benzole, mobile, insoluble in and of less specific gravity than water, the lower halves of the two legs being filled with the water, which may be tinged pink with cochineal. To prevent evaporation, the surface of the water in the cisterns is covered with a film of oil. Should, however, the level of the two cisterns be disturbed from any cause, it can be restored by means of the stop-cock (E) connecting the two cisterns.



In the instrument as constructed the lighter fluid is benzole, in which camphor has been dissolved in sufficient quantity to obtain a specific gravity equal to eight-tenths that of water, or a difference of one-fifth.

The scale, with which the instrument is fitted, is divided in this latter proportion, so that each one-tenth of an inch pressure, in inches of water column, is represented by five-tenths of an inch on the scale. These divisions being again subdivided, a variation of one-hundredth of an inch of water column may be clearly read.

A screwed wire, suspended from the bend of the tube by a brass clip, carries the scale, which can be moved by the milled nut (F), to adjust the zero of the scale to the points of contact of the two fluids.

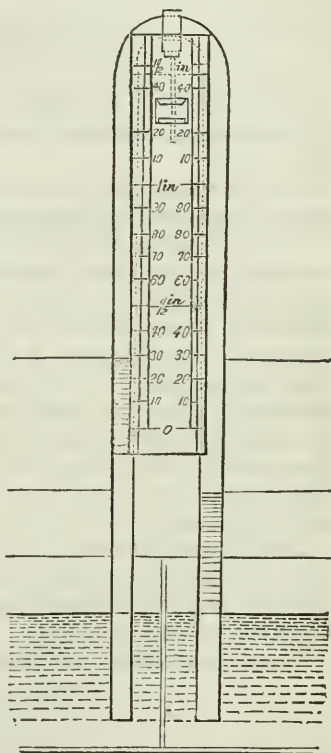
The action of the instrument is as follows: Any excess of pressure in the air-tight cistern (B) raises the level of the water in the leg (G) of the syphon tube, and causes a corresponding depression in the other leg (H), and the amount of variation between the two water-levels will be inversely proportional to the difference between the densities of the two fluids.

It will be seen that, assuming the difference of level in the two legs to be one inch, and, drawing lines across the figure at the two points, (see Fig. 2,) that the benzole in each leg above the higher level, being equal, is balanced, as is also the water below the lower level. There only remains, therefore, the inch of water on the one side against the inch of benzole on the other; consequently, the amount of pressure expressed in inches of water will be equal to the difference between the weight of the two columns, which difference in this case (one-fifth of an inch) is represented on the scale by a distance of one inch, thus giving a scale magnified five times.

I should be glad to hear of a suitable fluid of a density approaching nearer to that of water, as the less the difference between the two fluids, the larger the scale becomes.

It need hardly be pointed out that the instrument can also be used to indicate negative pressure, the action in the tube being merely reversed, and the reading taken from the opposite column, as in the case of a chimney draft.

No 2.



Artificial Ivory.

From the London Journal of the Society of Arts, No. 680.

The *Mechanics' Magazine* says that the process by which the most successful imitation of natural ivory is obtained appears to consist in

dissolving either india rubber or gutta percha in chloroform, passing chlorine through the solution until it has acquired a light yellow tint, next washing well with alcohol, then adding, in fine powder, either sulphate of baryta, sulphate of lime, sulphate of lead, alumina, or chalk, in quantity proportioned to the desired density and tint, kneading well, and finally subjecting to heavy pressure. A very tough product, capable of taking a very high polish, is obtainable in this way.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, March 21st, 1866.

The meeting was called to order with the President, William Sellers, in the chair.

The minutes of the last meeting were read and approved. The minutes of the Board of Managers were reported.

At the meeting of the Board of Managers, held on the 14th inst., donations to the library were received from the Royal Astronomical Society, the Statistical Society, and the Society of Arts, London, England; James Swaim, Esq., and, through him, from MM. Rudolph Kœnig, Arthur Cavalier, L. Breguet, J. Salleron, J. A. Deleuil, and Eugene Lacroix, Paris, France; the Canadian Historical Society, Montreal, Canada; the Water Commissioners, Detroit, Michigan; and William Sellers, Esq., the Executor of the Estate of William J. Duane, deceased, Prof. John F. Frazer, M. Carey Lea, Esq., H. P. M. Birkinbine, Esq., Dr. T. S. Kirkbride, and J. F. Houston, Esq., Philadelphia.

The Committee on the Library reported that they had organized by electing Mr. Pliny E. Chase Chairman, and appointing the first Monday evening of each month for their stated meetings. They also reported their minutes.

The report of the Resident Secretary was then read, as follows:

SECRETARY'S REPORT.

A borax-yielding lake has been discovered in California, which promises to afford a large supply of that valuable salt. It is located near Clear Lake, 65 miles southwest of Suisun Bay, and 36 miles from the Pacific, in a region of country decidedly volcanic.

The borax lake is about 4000 feet long by 1800 wide at present, though there are indications that in former times its extent was much greater. Its present depth is 3 feet. The water contains a large percentage of borax, but what is of more importance, a solid bed of this substance, in crystalline condition, lines the bottom of the whole lake. This solid salt is taken out by means of movable coffer-dams, and is found to be remarkably pure.

During the dry season of 1865, 240 tons, at the rate of $2\frac{1}{2}$ tons per day, were removed, 40 tons of which were used in the California mint, and 200 tons were shipped to New York.

Very near this lake is a considerable deposit of sulphur, where solfatara action is still going on, and also a hot spring, charged with a very large per centage of borax and carbonate of ammonia.

Mechanics.—There have been presented this evening for examination the following new inventions and mechanical adaptations:

Lyon's National Lifter, or Portable Crane, so arranged that it may be readily run from place to place, and set up by one man, and yet capable of lifting at least 10 tons.

A pulley with cam wheel, so arranged as to clamp the rope and prevent it from running back if the hoisting end should be broken or suddenly abandoned. Invented by R. T. Knight of this city.

A gas regulator, in which the flow of gas to a series of burners is regulated under changing conditions of pressure and consumption, by means of a valve controlled by a gasometer floated upon mercury. Invented by John H. Cooper of this city.

An altiscope or telescope, so arranged by a combination of mirrors and lenses as to enable an observer to look over or around an opaque object. This instrument is invented by John Clark, Esq.

A new arrangement of bar vice, invented by Mr. Linus Yale, was then presented, and, at the request of the Secretary, described by Mr. Coleman Sellers, as follows:

MR. PRESIDENT: At the request of Mr. Linus Yale, Jr., of Shelburn Falls, Mass., I would call your attention to a parallel jaw or bar vice. This tool he designed to obviate a difficulty existing in all ordinary vices, the jaws of which are moved by a screw, viz: the time lost in opening and closing the jaws by the tedious process of turning the screw. In some kinds of work, such, for instance, as the manufacture of locks, the case of the lock requires to be held edgeways, and then flatways. This necessitates the jaws being opened through considerable distance, and then closed as each change is made in the way of holding. Mr. Yale, in noticing his workmen at this kind of work, found that 12 per cent. of their time was spent in screwing and unscrewing the vice. The instrument which I now show to you has a nut and screw with the bar, as usual, but the nut is not always attached to the bed or stationary jaw of the vice. To this jaw, in the under part of the guide, is a rack with ratchet teeth. The nut is square, and has teeth on its under side, corresponding to the teeth in the rack. The nut, when screwed to the back end of the bar, rides up an inclined plane, which so elevates it above the rack, that its teeth cannot engage therein. In this position the movable jaw can be pushed back and forth, *i. e.* opened or closed rapidly by hand without turning the screw. Placing a piece of work in the vice, as, for instance, this piece of wood, about three-eighths of an inch thick, you perceive I can push the jaw quickly up to it, and then one turn of the screw draws down the nut into the rack teeth, and a part of a turn will secure the work as firmly as if screwed in an ordinary vice. The same amount of back turns of the screw release it, and then the jaws can be opened wide to receive the block edgeways. They are about three inches open now, and one turn, &c., will again fasten it. The vice can be

used as an ordinary vice, by drawing out the movable jaw to any required distance, and then screwing it all the way home. It will, within the range to which it was opened, act as if the nut was fast to the stationary jaw. The rack in this vice is not rigid. It has a spring back of it so arranged as to allow one-eighth inch end motion. This enables the workman, when filing to a template, to adjust his work to the template with a slight pressure of the jaws, the movable jaw being elastic as it were. See! I can pull it back about one-sixteenth of an inch, yet the work is held firm enough to adjust. Workmen will appreciate this; for they are aware that in a rigid vice the work must be either very fast or very loose.

The tool seems to me to be a very useful one, indeed, and I would move that it be referred to the Committee on Screws and Nuts, for their examination. *Carried.*

In the late reports of the Society for the Encouragement of National Industry, (French,) we notice one at some length on a plan for the use of liquefied ammonia, in place of water, as a means of utilizing heat force, as in the steam engine.

In this report the whole subject of such substitutes is discussed, and it is shown that their introduction is founded upon a false inference. Because a slight elevation of temperature produces a great increase in the elastic force, tension, or expansion of such bodies, it is supposed that by these means more work may be obtained from a given amount of heat than by the use of a substance which, like water and steam, suffers less expansion by an equal change of temperature. In this case, however, the fact is forgotten that these first-named bodies have a latent and specific heat corresponding to their property of dilation, so that, after all, a given amount of heat produces the same amount of work or mechanical effect, though the temperatures concerned may be very different; for, in the case of the liquefied gas, where a great elastic force is developed by a slight increase of temperature, a large amount of heat is required to produce that slight increase, being expended as latent and specific heat, while in the case of steam, though less elastic force is developed by the same rise in temperature, a less amount of heat is required to effect this change.

In the same publication we notice a good arrangement for a safety lamp, by which the removal of the protecting cylinder of wire gauze is made instantly to extinguish the light.

Chemistry.—At a late meeting of the London Pharmaceutical Society, Mr. Haselden read a paper, in which was suggested a new application of the very useful substance—glycerine. By mixing with a pound of softened gelatine an ounce and a half of glycerine, an elastic material may be formed of great efficiency in capping or sealing bottles.

At the same meeting a new adulteration of saffron was described, and its mode of detection pointed out, which was either by the use of the microscope or by soaking in water, when pollen granules will separate and sink from the mass, if the stamens of the saffron flower, (*crocus sativa*,) which constitute this adulteration, are present.

Kuhlman, who has given much time to the study of the coloration

of minerals, and their power of absorbing various organic substances, states that, if plaster of Paris, with enough water in it to give it the constitution $\text{CaO}, \text{SO}_3 + 2\text{H}_2\text{O}$, is steeped in a bath of hot pitch, it loses its two equivalents of water, which are replaced by a corresponding quantity of pitch, and that it then becomes very hard and susceptible of a polish, so that it would be available for the construction of many articles for ornament or use.

The subject of coppering and bronzing by the use of alkaline solutions is discussed at some length, in the *Annales de Chimie et de Physique*, by M. F. Weil. The important points involved in the process seem to be that the presence of organic matter, such as glycerine, albumen, tartaric acid, and the like, prevents the precipitation of a metallic oxide from an alkaline solution, but that when a galvanic action is established between the article to be plated and a piece of zinc (both immersed in the alkaline bath) the metal is deposited with facility.

Deodorizing and Disinfecting.—Dr. J. H. Barker, summing up the results of many experiments, makes the following statement. The most efficient means in various cases are as follows :

- 1st. For the sick room, free ventilation.
- 2d. For rapid action, chlorine.
- 3d. For steady and continuous effect, ozone.
- 4th. Next to ozone, solid iodine.
- 5th. For decomposing fluids, tincture of iodine.
- 6th. For solids, powdered chloride or sulphate of zinc with sawdust, carbolic acid and sawdust, or lastly, wood ashes.
- 7th. For clothing, a heat of 212° .
- 8th. Anything which may be destroyed should be burned up.

Ozone.—The well known chemical writer, Frémy, says, in a late report to the Academy of Sciences, that the only certain test for the presence of ozone is the oxidation of a bright surface of silver, and that, by this test, the presence of ozone in the atmosphere has never been proved. The iodized starch paper is affected by a multitude of agents, always present in the atmosphere, and is therefore of no value in this respect.

M. Soret presents a note to the Academy on the density of ozone, which, from various indications, he calculates to be 1.658.

Déville, in a late note on the hydraulicity of magnesia, states that a piece of compact anhydrous magnesia, left under a water-tap for several months, became perfectly hard and transparent as alabaster.

Busts like marble may be made of equal parts of this anhydrous magnesia (which is obtained by treatment of the chloride derived from sea-water) and powdered marble, pressed in moulds, and then exposed for some time to the action of water.

A dolomite, rich in magnesia, calcined and ground, forms under water a stone of very remarkable hardness.

To preserve specimens without the use of alcohol, a writer in *Silliman's Journal* gives, as the result of many experiments, minute directions for the preparation of several solutions of rock-salt and nitre of gradually increasing strength, and for the successive soaking of the

specimens in these, by which means they are uniformly charged with the salts in question, and preserved in a most satisfactory manner.

We see, by an article of some extent, published in the above journal, that the process of sodium amalgamation, lately patented in England by Prof. Crooks, was patented some time before in this country by Henry Wurtz.

It is stated that metallic titanium has been manufactured in some quantity, at Birmingham, by reduction with sodium.

There were then exhibited, by the Secretary, some persistent soap bubbles, made from a mixture of oleate of soda and glycerine, prepared by Mr. James T. Shinn, according to the formula published in the *American Journal of Pharmacy*, March, 1866, page 99. These may be blown of a convenient size, 6 or 8 inches in diameter, and set upon wine glasses, and, if covered with glass shades or bell jars, will remain unbroken for more than 24 hours, or they may at once be blown to enormous size, may be dropped upon and will rebound from a carpet, may be cut with scissors, (wet with the solution,) and have other bubbles blown within them. Their beauty and curious effect is very remarkable.

Aqueous Lines in the Solar Spectrum.—Prof. Crooks, by a series of observations with the spectroscope, made especially during a period of very damp though clear weather, has shown that the vapor of water in the atmosphere has a very great effect in the production of absorption bands, so that in one case he found the total number visible in the spectrum increased ten-fold by this cause.

These lines abound in the red and yellow part of the spectrum, and they thus explain the blue color of the sky, (deepest in summer, when most moisture is present;) for these lines indicate an absorption of the red and yellow rays, leaving, therefore, the blue in excess.

A writer in the *London Chemical News* constructs bisulphide of carbon prisms in the following simple manner: A piece of sheet brass is cut into a hexagonal shape. Two opposite angles are bent at right angles to the middle part, thus forming a skeleton prism, with one solid brass face. On the open faces plates of glass are secured with paper soaked in a mixture of gelatine and glycerine, with which the interior is also smeared. A small hole is made in the brass to introduce the bisulphide.

A small electro-magnetic engine was exhibited, in which the coils of the electro-magnets were made of uncovered wire. This was presented by James Queen & Co., and operated with perfect success. The fact that coils might be thus constructed was first published about a year since by Du Moncel.

After the conclusion of the Secretary's Report, Prof. Ward gave a description of his process for marine signals.

The meeting was then, on motion, adjourned.

H. MORTON, *Secretary*.

Erratum.—The name of Henry G. Morris was omitted in the list of the Committee on the Library, printed in the last minutes.

A Comparison of some of the Meteorological Phenomena of FEBRUARY 1866, with those of FEBRUARY, 1865, and of the same month for FIFTEEN years, at Philadelphia, Pa. Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½' N.; Longitude 75° 11¼' W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	February, 1866.	February, 1865.	February, for 15 years.
Thermometer—Highest—degree, .	60·00°	56·00°	70·00°
“ date, .	11, 23, & 24th.	26th.	23d, '60.
Warmest day—mean,	55·00	49·17	59·30
“ date, .	24th.	26th.	25th, '57.
Lowest—degree, .	7·00	3·50	—1·00
“ date, .	16th.	13th.	7th'55; 8th'61.
Coldest day—mean,	15·00	12·00	4·50
“ date, .	16th.	13th.	6th, '55.
Mean daily oscillation,	13·11	11·34	13·38
“ range, .	7·42	5·97	7·22
Means at 7 A. M., .	30·87	28·45	29·39
“ 2 P. M., .	39·16	36·20	38·43
“ 9 P. M., .	35·68	32·44	33·60
“ for the month,	35·24	32·36	33·81
Barometer—Highest—inches, .	30·547 ins.	30·322 ins.	30·671 ins.
“ date, .	17th.	21st.	4th, '63.
Greatest mean daily press.	30·475	30·293	30·595
“ date, .	26th.	21st.	12th, '57.
Lowest—inches, .	29·392	29·256	29·065
“ date, .	14th.	8th.	23d, '53.
Least mean daily press.,	29·529	29·347	29·227
“ date, .	1st.	8th.	16th, '56.
Mean daily range, .	0·245	0·205	0·222
Means at 7 A. M., .	30·032	29·872	29·924
“ 2 P. M., .	29·964	29·849	29·876
“ 9 P. M., .	29·999	29·875	29·909
“ for the month, .	29·998	29·865	29·903
Force of Vapor—Greatest—inches, .	0·424 in.	0·326 in.	0·549 in.
“ date, .	24th.	26th.	16th, '57.
Least—inches, .	·048	·044	·013
“ date, .	16th.	13th.	6th, '55.
Means at 7 A. M., .	·151	·124	·139
“ 2 P. M., .	·170	·134	·158
“ 9 P. M., .	·175	·137	·157
“ for the month, .	·165	·132	·151
Relative Humidity—Greatest—per ct.,	95·0 per ct.	100·0 per ct.	100·0 per ct.
“ date, .	8th.	23d.	often.
Least—per ct.,	30·0	35·0	20·0
“ date, .	1st.	24th.	22d, '64.
Means at 7 A. M., .	79·9	75·1	78·5
“ 2 P. M., .	65·2	61·4	63·2
“ 9 P. M., .	76·1	71·7	75·1
“ for the month	73·7	69·3	72·3
Clouds—Number of clear days,*	13	8	8·5
“ cloudy days, .	15	20	19·7
Means of sky cov'd at 7 A. M.,	45·7 per ct.	58·2 per ct.	60·4 per ct.
“ “ “ 2 P. M.,	58·9	58·9	60·7
“ “ “ 9 P. M.,	41·1	61·8	47·7
“ “ for the month	48·6	59·6	56·3
Rain and melted snow—Amount,	6·637 ins.	5·491 ins.	3·174 ins.
No. of days on which rain or snow fell,	8	10	9·9
Prevailing Winds—Times in 1000,	N70°38'W·265	N65°18'W·351	N74°23'W·283

* Sky one-third or less covered at the hours of observation.

A Comparison of some of the Meteorological Phenomena of the WINTER of 1865-66, with that of 1864-65, and of the same Season for FIFTEEN years, at Philadelphia, Pa. Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½' N.; Longitude 75° 11¼' W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	Winter, 1865-66.	Winter, 1864-65.	Winter, for 15 years.
Thermometer—Highest—degree, .	63-00°	59-00°	71-00°
“ date, .	Dec. 27th.	Dec. 7th.	Dec 2, '59
Warmest day—Mean,	55-33	52-33	62-80
“ date, .	Dec. 4th.	Dec. 3d.	Dec. 19, '56
Lowest—degree, .	—9-00	3-50	—9-00
“ date, .	Jan. 8th.	Feb. 13th.	Jan. 8th, '66
Coldest day—Mean,	2-67	12-00	—1-00
“ date, .	Jan. 8th.	Feb. 13th.	Fe. 7, '55; Fe. 8, '61.
Mean daily oscillation,	12-29	11-02	12-51
“ range, .	7-16	6-83	6-76
Means at 7 A. M., .	31-23	28-07	29-73
“ 2 P. M., .	37-99	34-89	37-64
“ 9 P. M., .	34-05	31-75	33-15
“ for the Winter,	34-42	31-57	33-51
Barometer—Highest—Inches, .	30-757 ins.	30-411 ins.	30-757 ins.
“ date, .	Jan. 8th.	Dec. 9th.	Jan. 8th, '66
Greatest mean daily press.	30-665	30-362	30-665
“ date, .	Jan. 8th.	Dec. 9th.	Jan. 8th, '66
Lowest—Inches, .	29-392	29-071	28-941
“ date, .	Feb. 14th.	Dec. 21st.	Jan. 23, '53
Least mean daily press.,	29-226	29-275	29-086
“ date, .	Dec. 19th.	Dec. 21st.	Jan. 23, '53
Mean daily range, .	0-211	0-235	0-217
Means at 7 A. M., .	29-992	29-839	29-944
“ 2 P. M., .	29-941	29-791	29-900
“ 9 P. M., .	29-978	29-828	29-931
“ for the Winter,	29-971	29-819	29-925
Force of Vapor—Greatest—Inches, .	0-509 in.	0-438 in.	0-551 in.
“ date, .	Dec. 27th.	Dec. 7th.	Dec. 2, '59
Least—Inches, .	0-24	0-44	0-13
“ date, .	Jan. 8th.	Feb. 13th.	Feb. 6th '55
Means at 7 A. M., .	0-152	0-127	0-139
“ 2 P. M., .	0-160	0-136	0-158
“ 9 P. M., .	0-163	0-142	0-153
“ for the Winter,	0-158	0-135	0-150
Relative Humidity—Greatest—per ct.,	100-0 per ct.	100-0 per ct.	100 per ct.
“ date, .	Jan. 15th.	Feb. 23d.	often.
Least—per ct.,	30-0	26-0	20-0
“ date, .	Feb. 1st.	Dec. 1st.	Feb. 22, '64
Means at 7 A. M.,	79-6	77-8	78-5
“ 2 P. M.,	63-9	63-8	65-3
“ 9 P. M.,	76-6	74-0	75-5
“ for the Winter,	73-4	71-9	73-1
Clouds—Number of clear days,*	27	20	25-8
“ cloudy days, .	63	70	64-4
Means of sky cov'd at 7 A. M.,	63-4 per ct.	60-5 per ct.	62-7 per ct.
“ “ “ 2 P. M.,	59-1	67-5	62-3
“ “ “ 9 P. M.,	52-5	61-7	48-6
“ “ for the Winter,	58-3	63-2	57-9
Rain and melted Snow—Amount, .	15-199 ins.	13-843 ins.	10-255 ins.
No. of days on which Rain or Snow fell,	27	41	31-1
Prevailing Winds—Times in 1000,	N 77° 4' W .254	N 75° 7' W .267	N 65° 46' W .290

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

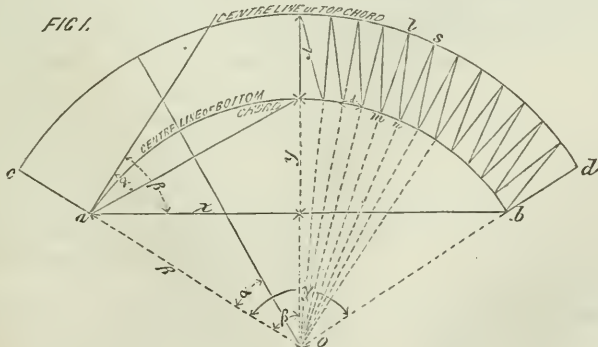
MAY, 1866.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Camber in Bridges. By ALFRED P. BOLLER, C.E.

The following investigation of the question of camber in bridges may be of interest and use to the younger members of the profession, and in that hope and spirit I submit it. In a horizontal truss, composed of top and bottom chords, diagonals, and verticals, the panels formed by the verticals are rectangular, the diagonals being simply the diagonals of rectangular figures. But where the beam is curved, or has a camber introduced, (which is measured by the versed sine of the curve at the centre of the chord line,) these verticals become the radii of a circle, of which the curved chords are arcs, and the diagonals are lengthened.



Take, as in the figure, an exaggerated case, letting ab and cd represent the arcs formed by the bottom and top chords, respectively,
VOL. LI.—THIRD SERIES.—No. 5.—MAY, 1866.

and also let n equal the number of panels, d being their distance from centre to centre, measured along the centre line of the bottom chord.

Let γ = depth of truss, or rather, the distance between the centres of gravity of the top and bottom chords.

y and x = the camber and half span.

R = radius of the arc ab .

β, γ, θ = angles as marked on diagram.

n, d, x , and y are given, also ab equal $n d$.

The trussed beam being built in a curve, the upper chord must, of course, be lengthened by an amount proportional to the radius of curvature, which produces a change in the panels, causing them to be longer along the top chord than along the bottom chord. The amount of this increased length is, of course, the same for every panel. The length

of the top chord is represented by $\frac{\pi \rho v}{180} = 0.0175 (R + r) v$, in which

$v = \gamma$. Therefore the total amount increase in the length of the top chord over the bottom chord is

$$0.0175 (R + r) v - n d = \delta, \quad . \quad . \quad . \quad (1.)$$

To find the radius of curvature, R , we have

$$\tan \alpha = \frac{y}{x}; \beta = 2 \alpha; \gamma = 4 \alpha; \text{ and } \theta = \frac{\gamma}{n}, \quad . \quad . \quad . \quad (2.)$$

$$\sin \beta = \frac{x}{R}, \text{ and } R = \frac{x}{\sin \beta}, \quad . \quad . \quad . \quad (3.)$$

Now, the number of panels being n , and the amount of *total* increase being δ , the lengthening for each panel along the top chord is—

$$\frac{n}{\delta} \quad . \quad . \quad . \quad . \quad (4.)$$

To find the length of the diagonals, let (Fig. 2) represent one panel, o being the centre of the curvature. We have $r' n s = \frac{1}{2} \theta = r'' l m$;

$$r'' m = \frac{n}{2 \delta}, \cos \frac{1}{2} \theta = \frac{l r''}{m l}, \text{ and } l r'' = \cos \frac{1}{2} \theta \times m l.$$

Then, from the right angled triangle $l r'' n$, there results—

$$ln = \sqrt{r'' l^2 + r'' n^2}, \quad . \quad . \quad . \quad (5.)$$

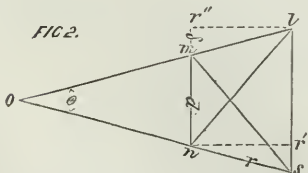
which is the length of diagonal.

Take as an example the camber in the proposed wrought iron International Bridge, to be built at Buffalo, over the Niagara River, which is intended to be six inches. r is 20.75 feet, the number of panels 24, and 10.7 feet, from centre

to centre, along centre line of bottom chord.

$$ab = 10.7 \times 24 = 256.8.$$

$$\tan \alpha = \frac{y}{x} = \frac{.50}{128} = .003907 = 0^\circ - 13' - 30''.$$



$$\beta = 0^\circ - 27'; \gamma = 0^\circ - 54', \text{ and } \theta = 0^\circ - 2' - 14''.$$

$$\sin \beta = \frac{x}{R}, \text{ and } R = \frac{x}{\sin \beta} = \frac{128}{\sin 27'} = \frac{128}{.00785} = 16,305.7 \text{ feet.}$$

Length of cd ,

$$0.0175 (R + r) v = .0175 \times 16,326.4 \times \frac{9}{10} = 257.13,$$

$$cd - ab = 257.13 - 256.8 = 0.33 \text{ feet} = 4 \text{ inches.}$$

The amount that each panel is to be lengthened along the top chord is $\frac{4}{24} = \frac{1}{6}$ of an inch.

For the lengths of the diagonals we have—

$$r'ns = \frac{1}{2}\theta = 0^\circ - 1' - 07''; mn = 10.70; ns = 20.75.$$

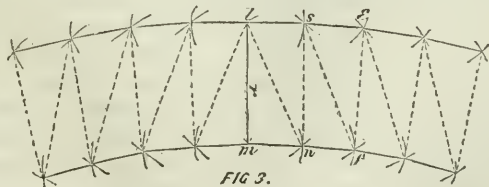
$$r''m = .0075; \cos 0^\circ - 1' - 07'' = \frac{lr}{m}, \text{ and } lr = 20.75 \times 1 = 20.75 \text{ feet.}$$

$$ln = \sqrt{r'^2 l^2 + r''^2 n^2} = \sqrt{545.21} = 23.35 \text{ feet.}$$

The practice among many excellent bridge mechanics is to distribute equally the amount of camber among the panels along the top chord, which always increases the amount of camber. For example: Instead of distributing equally *four* inches among the panels, found in the above case to be required for a six-inch camber, they would distribute *six* inches, which would give nearly one-third more camber.

When camber is properly constructed in a bridge, the bottom chords are not strained by tension until the deflection of the truss is so great as to pass the horizontal chord-line. *Until* then the whole truss acts like a flat arch, and consequently, when the camber is considerable, no deduction for loss of strength by area cut away need be provided for, as would be necessary for a straight built beam, when deflection to the slightest amount would call upon the bottom chord to resist tension.

The graphical construction of the camber, in designing a bridge truss, may be very readily accomplished by starting from the *centre vertical*, working both ways to the abutments. First measure off the distance between centres of gravity of sections of the top and bottom



chord along the centre vertical. Thus, in Fig. 3, lm is the vertical at centre $= r$ in formula; $mn = d$; $ls = d + \frac{n}{\delta}$, and ln is the calculated diagonal.

From the point m , with radius d , draw an arc, and with l as a centre, and the diagonal as the radius, cut this arc in n . With l as a centre, and $d + \frac{n}{\delta}$ as a radius, describe an arc, cutting it in s , using the diagonal as radius, with m as a centre. Repeat this same operation from the points n and s , to get the points e and f , and so on to the abutments. This method can be relied upon as simple, rapid, and accurate.

For the Journal of the Franklin Institute.

Sextant with Attached Spirit-level Horizon. By GEORGE DAVIDSON,
Assistant U. S. Coast Survey.

It very frequently happens that the traveler and the navigator are placed in situations where it is in the highest degree desirable to determine their geographical positions, or to measure the elevation of some mountain by an altitude or depression, and yet the means at their command may be inefficient. At sea, the sextant is the best available instrument for measuring angles of elevation or azimuth, but for the former purpose it can be used only when the object and sea horizon are both visible. Sometimes, however, when it is very desirable to measure an altitude, the sun is so low that the bright and dazzling reflection from the surface of the water obscures the horizon; or the horizon is hidden by a low fog whilst the sun is visible through it.

On shore, the traveler, whose outfit of astronomical instruments is limited to a pocket chronometer, sextant, and artificial horizon, finds constantly annoying occasions when his means fail him in important determinations. The sun may be too high for observing double reflections with the ordinary sextant; the sun or a mountain may be too low to admit of available reflection in the artificial horizon; and in particular these means positively fail him when, from any elevated point, he wishes to measure the depression of some object, as of the sea horizon, by which to determine his elevation or distance, knowing one of them, or, knowing the distance of another and lower mountain, to determine the difference of elevation.

We have encountered all these difficulties, and also the less frequent one of falling in with a reef at night with the stars visible but the sea horizon totally obscured in darkness. This occurrence first directed our attention to the subject of adjusting an artificial horizon to the sextant about twelve years since, but we failed to solve the problem. Three years since, when daily using the hand-level generally known to the trade as Locke's level, we saw the means at our hand ready for application, and fitted it to a Gambey sextant.

Plate IV. shows this level in detail. Fig. 1 gives the general appearance of the sextant and the attached level; Fig. 2 is a transverse section through the bubble, cross wire, and reflector; Fig. 3 is a longitudinal section through the bubble, reflector, and double convex lens. The tube B carrying the spirit-level is closed at each end with

Sextant with Spirit Level Horizon, by George Davidson, Asst. U.S. Coast Survey.

Scale $\frac{1}{16}$

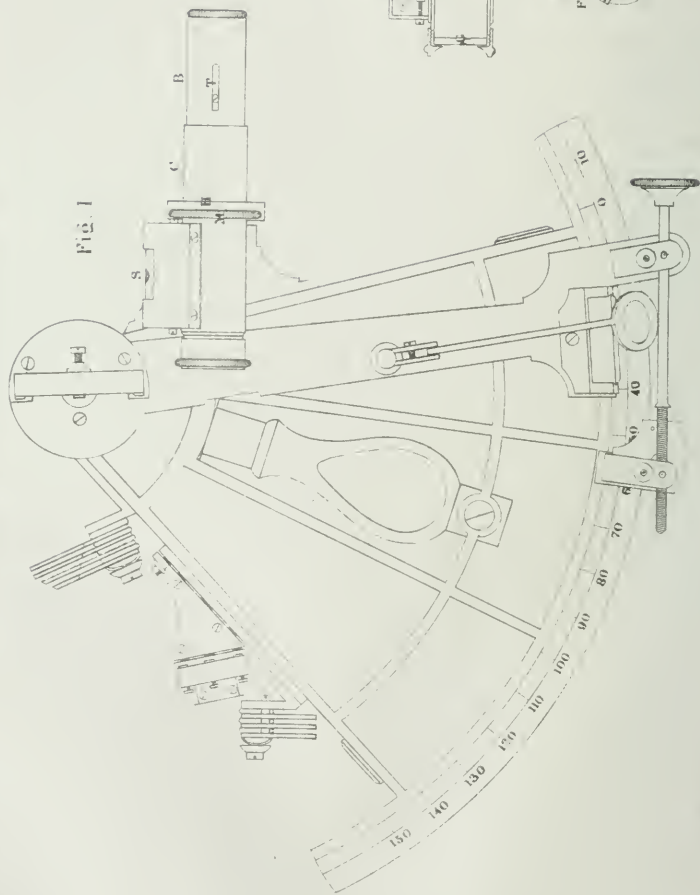


Fig. I

Fig. III.

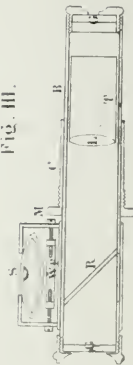


Fig. II.



plane glasses G G; the half of the tube lengthwise and on the side nearer the face of the sextant is unoccupied from end to end to permit vision directly through the plane glasses to any object or reflected object, whilst the other half carries the reflector R, having its reflecting surface towards the observer and placed at an angle of 45° with the axis of the tube, which also carries the half or segment of a double convex lens L secured in the inner tube T, which is capable of adjustment for difference of vision in different observers. Towards the object end of the tube B, over an opening above the reflector, is secured a small spirit-level S, with its axis parallel to the tube, and having, immediately beneath the tube, an adjustable frame F carrying a fine wire W at right angles to the axis of the tube and parallel to the horizontal plane. The images of the bubble of the spirit-level and of the cross wire are reflected through the lens to the eye of the observer. Other equivalent means may be employed for the above purposes, such as a prism for the reflector, &c.

For observations on land, where the instrument may be held with more steadiness than at sea, or even secured to a fixed object, a small telescope, such as the weakest power usually furnished with the sextant, may be fitted to the eye end of the tube, and thereby afford better results.

We have affixed the level to the sextant by having a tube C, about one inch in length, with a milled head M and exterior screw collar to screw into the telescope holder U of the instrument, and then sliding the tube B into it. This permits the use of the usual telescopes by removing the tube C.

The adjustment of this level is made either by changing the angle of the reflector, or moving the frame carrying the cross wire, or by elevating one end of the level itself; and consists in making the image of the cross-wire bisect the image of the bubble when a distant object in the same horizontal plane and seen through the unoccupied half of the tube appears on a level with the image of the cross-wire. This adjustment is readily effected on land, may be made by means of the level itself, and is not easily deranged. Should it, however, become necessary to adjust the level at sea, the image of the cross-wire, when it bisects the image of the bubble, is made to appear on the same line with the visible horizon; and the correction for the dip of the horizon at the given height of the observer's eye is applied to all observed altitudes and depressions.

The index error may be determined when the level is adjusted on land and used as a constant quantity for a not very extended series of observations, or it may be determined at sea whenever the horizon is visible, by observing the depression of the horizon and taking the difference or sum of the observed result and the computed dip for the index error.

The operation of making an observation for the altitude or depression of any object at sea or on land is as follows: Secure the level in its proper place on the instrument and hold the sextant in the usual manner, with the plane of its face in the vertical plane passing through

the object and the observer. Looking through the tube, move the vernier arm until the image of the object is seen through the unoccupied half of the tube, and bring that image into the same horizontal line with the image of the cross-wire at the time it bisects the image of the bubble, and if necessary note the time by chronometer. If the sextant and the level are in adjustment, the reading on the arc indicated by the vernier is the observed altitude or depression of the object.

At night, observations may be made by illuminating with a lamp or by chemical means. We have observed the altitude of the moon without any artificial light. Prof. Frazer suggests, as a chemical means of illumination, a small tube, containing phosphorus in oil, capable of being placed over the level at pleasure, and a small quantity of air admitted when the instrument is required for night observations. The length of the bubble of the unground level we experimented with was two-tenths of an inch, but should be shorter. The level had a radius of curvature of fifty-six inches, but for sea observations it may be smaller for bad weather and until practice be acquired.

The following results from observations for latitude are given as exhibiting what was done at the second and third trials with the instrument. It is believed that, with practice and a level adapted for the duty, much better results can be obtained, especially in the hands of a more experienced observer with the sextant.

Latitude from circummeridian altitudes of the sun with sextant and spirit-level horizon. Observations of November 11th commenced 5 min. 48 sec. before apparent noon, and ended 11 min. 18 sec. after noon. November 12th commenced 7 min. 23 sec. before, and ended 5 min. 55 sec. after apparent noon.

NOVEMBER 11, 1865.		NOVEMBER 12, 1865.	
$\odot$	$\odot$	$\odot$	$\odot$
39° 59' 18"	39° 57' 14"	39° 60' 12"	39° 54' 19"
55' 55"	57' 36"	59' 28"	56' 37"
57' 05"	57' 18"	57' 51"	56' 31"
56' 52"	58' 41"	57' 39"	58' 13"
57' 55"	59' 43"	56' 01"	57' 51"
55' 52"	61' 27"	56' 59"	58' 29"
58' 41"		58' 54"	59' 01"
Means, 39° 57' 23"	39° 58' 38"	39° 58' 09"	39° 57' 17"

These reductions have been unnecessarily made to seconds of arc that the actual working of the instrument may be seen; the probable error of one observation deduced from these series is one minute of arc, and the probable error of the mean of all the observations is thirty-five seconds of arc. This, of course, excludes whatever constant errors may have existed.

The following observations were made for index error :

November 11, 1865. Off the Arc.		November 12, 1865. Off the Arc.	
+ 0' 46"	+ 1' 50"	+ 1' 50"	+ 1' 20"
3 20	2 20	4 20	1 20
3 20	3 40	2 20	2 50
4 00	3 10	4 30	1 20
2 30	1 10	1 50	3 30
3 40	2 10	2 50	1 50
Mean, + 2' 39"		Mean, + 2' 30"	

And the probable error of one observation is three-quarters of a minute of arc.

Observations for error of chronometer have been made with the instrument, and it has been used to measure the difference of elevation of objects above and below the plane of the observer when it was impossible to get their reflection in the ordinary artificial horizon.

A thorough trial will be made of this improvement this season, when the results can be compared directly with the determinations of the Coast Survey.

*Fire-proof Materials and Construction.** By T. HAYTER LEWIS,
F. R. I. B. A.

From the London Civil Engineer and Architect's Journal, August, 1865.

In connexion with the use of iron, and of the metals generally, in building construction, it may be remarked that the softer ones, as lead and zinc, are, of course, fit only for covering, and do not enter much into the subject. But in thinking of them for roofing, we must remember that zinc melts at a low heat (700°) and then burns fiercely. Lead melts at a somewhat lower temperature, (594°.) Iron, however, is a great aid now in construction, and its almost universal use suggests the need of most careful research with respect to it. Now, undoubtedly, it is relied upon by the public as being a safeguard against fire. Undoubtedly, too, its use is looked upon by the insurance offices as being more dangerous than that of wood. Its first and most obvious defect is its rapidly deteriorating strength when heated, and though the fact is well known, it is curious that experiments vary very much indeed as to the measure of deterioration. All agree in the fact that at and above red heat, (which is common enough in fires,) the diminution in strength is great; but below that opinions differ much. Mr. Braidwood's opinion was that iron begins to lose its strength even at such low temperature as 100° and upwards. Mr. Hodgkinson thought that the strength was only slightly diminished at any temperature under 600°, (the melting point of cast iron being 2786°,) and was not very much so until red hot, and the experiments made by him and Mr. Fairbairn are by no means clear in their results. It is highly important that the exact facts should be ascertained, because, of course, a

* Excerpt Proceedings Royal Institute of British Architects. Session 1864-65.

low temperature is more common than a high one. My own opinion, from careful observation after every case of consequence, is that wrought iron is very sensibly weakened, and cast iron rendered brittle at comparatively low heats; because it is very common to find iron ties and other similar work bent merely by their own weight, in small buildings and other places where the heat has clearly, from other evidence, not been great. The failure of the wrought iron girders also, drawn from examples at a recent fire, shown on the drawings, tend to the same conclusion, for the whole of them were bent, twisted, or broken in the most violent way, although the cast iron columns on which they rested were only slightly bent. These columns were, however, of much stronger form than is usually found. Anyhow it is quite certain that at higher temperatures, such as are to be expected in a large fire, iron rapidly loses strength, and thus a floor or a beam which would bear the weight upon it quite safely at an ordinary temperature, might break down at a higher one. But I come now to consider of the greater heats constantly produced in our larger fires, and where iron and brass are actually melted. (Specimens of both taken from a recent fire were exhibited.) The temperature here must have been about 3000° , and the metals retained no strength whatever to sustain even their own weight. Now, there can be no doubt that iron offers us most admirable aid with our columns and girders, when used as metals should be; and now that we are getting out of the way of imitating stonework in iron, and that we are using and ornamenting iron as a definite material, undisguised, it is likely to influence, and ought to influence most materially, our designs; and when we call to mind the extraordinary differences produced in its qualities, by such comparatively trifling differences in treatment as those which produce cast iron, wrought iron, and steel, annealed and case-hardened iron, we may not be without hope that means may be found of removing the defects which now militate so seriously against its use. Meanwhile we must look upon it as being a most dangerous ally.

Wood is not quite so dangerous a material as is supposed. For instance, I have seen some posts and a girder which remained to the end of the fire which melted the iron and brass within 10 or 12 feet of them. A piece of another post from the same building, and close to the same part of it, where the wood was burnt in to some little distance, and scorched deeply in, yet still retained its strength. Several others remained in the same state, and in ordinary fires large timbers are seldom burnt right through, but have enough of their substance left to act as struts or girders, though, of course, much weakened. Doubtless, in the case of such extreme heat as above, there is some current of air which carried the flames away from the wood; but none of the firemen present could say how.

I come next to *concrete*. This is much used for fire-proof floors, and likely to be for many other purposes, as bricks are now getting so very dear. We know well, from the examples of old walling, how valuable a material this is, as we have all seen it remaining quite sound after being used for the hearting of a wall, after its Roman or Me-

diæval casing has been destroyed for ages. But, so far as my present purpose is concerned, we must accept its use with some reservation. The whole question was entered into very fully by Mr. Tite and others at the Institute, in the discussion on Mr. Burnell's paper, and his opinion was that ordinary concrete was not to be trusted. Clearly flint-work is unsafe, as the flint is calcined so much by fire that walls made of them are shattered to pieces by it. So are the ordinary gravel pebbles, of which here are some specimens. But concrete may be made of broken bricks, as the old Romans made it, and as, I think, Mr. Tite has used it in several cases. I have a high opinion of concrete in fire-proofing, but there have been, nevertheless, cases of some suspicion as to the perfect protection to be derived from its use.

The last substance to which I shall allude in detail is ordinary plaster—perhaps the most valuable auxiliary that we have—as might be expected from its non-conducting properties, proved clearly in the very elaborate experiments made on this subject by Mr. Hutchinson. He tried most building materials carefully, and showed that a combination of lime, sand, plaster of paris, &c., had less conducting power than any of the others.

I must now consider the combination of these several materials in different forms of construction, and the subject will naturally come under the divisions of walls, piers, columns, or other detached supports, floors, stairs, and roofs. The walls are, of course, the most important, but the least difficult in execution, as brick is at once the best and most common material, for inside work at least. In fact it is, I think, an almost unexampled case for a fire to destroy an ordinary thick wall, as the flames naturally ascend, directing their force on the ceilings, through which they usually find vent; and I have seen fires of great strength stopped even by thin partitions. I saw one case, in the old town of Hamburg, where a large warehouse was destroyed, but where the fire had not injured the adjoining warehouse, although separated from it by brick nogging only. Sometimes, however, there is such a stop to the flames from a stubborn ceiling or arch, as to allow them no decided vent, and then the walls are exposed to the full action of the fire. Yet even then I have never known good brick walls to fail by being burnt in. There was a great proof of their strength in the case of the vaults of the Tooley Street warehouses, many of which were filled with oil, converted by the flames into a rolling sea of fire, which burnt for weeks. These vaults were built in the usual way of good groined arches, supported on brick piers, and not an arch nor a pier broke down under the trial, nor, after a recent examination of those that still remain, could I see that even a joint had given way. But every portion of the stores over, many of which were built of iron girders on iron columns, presented such a scene of utter ruin that one could scarcely dream of. No one who had ever seen it would place faith again in iron. The greatest damage is to be feared in time of winter, and when the fire is over; then, if one side of a wall has been saturated with water, and the other not so, the water

in the open joints freezes, expands, lifts the brickwork on the one side, and bends the wall. I must qualify this opinion as to the sufficiency of brick walls, by saying that the brickwork must be well done; for I have seen cases in which the work was filled in so badly, that smoke poured through the wall at every joint; there was, of course, but little safety there. I, of course, suppose that all the walls are of a fair thickness, but it would lead to too long a controversy to discuss here as to what that thickness should be. I must also qualify what I have above said, with respect to walls of hollow or pierced brick. For various reasons I much doubt the effect of fire upon them, but I have not seen them tried practically, so that I speak upon this part of my subject with hesitation.

Next to the walls come the piers and columns, and these are clearly the most important parts of the building. Their construction is often easy enough on the basement, where space is not usually so much an object; but above that story, anything larger than a story post or iron columns is seldom allowed. I have already alluded to the defects of iron, and at present I know of no method of insuring safety in its use. Several means have been suggested. Mr. Hosking tried, in one very extensive warehouse, the plan of putting the columns double in two separate rings, one, in fact, enclosed within the other, his idea being that if one were to break or bend, the other would safely bear the weight. I certainly doubt this much, and in any case the expense is very great, and the size of the columns very much enlarged.

I myself once tried the somewhat contradictory plan of encasing the iron columns with a thick layer of plaster. There is no great difficulty in getting the plaster firmly to adhere, and I think that the plan would be a safer one than that of the double columns. But I am not over sanguine about it, and the system is, at least, liable to the artistic objection that it conceals the more valuable material of the two. I have already alluded to the plan of sending air through the columns, but there is another plan which has found favor with many, and which provides for filling the columns and girders with water. This, at first sight, seems plausible enough; but the least thought shows numerous objections. There is, first, the risk of the water freezing, and so bursting the iron—or of the latter expanding, and so letting the water leak at the joints. There must be risk of this, even with ordinary changes of temperature, subject, as the floors must be, to heavy pressure, and still more so in case of fire when every circumstance is intensified to an extraordinary degree. We must, too, then find the hollows either open to the cistern head or closed securely; if open, the intense heat will convert the water into steam, and blow it out; and if closed, the heat will convert the hollow spaces into so many boilers, charged with steam at a high pressure, without escape valves, and tear the whole to pieces.

But the whole question of supports is intimately connected with that of the floors which they carry. Now, I will first take the case of private houses, where there is usually nothing but the ordinary furniture to burn beyond the constructive part. I assume, of course,

that such precautions have been taken as to make the skirtings and partitions solid, because if drafts are allowed through and beyond these the fire will soon be led through them in spite of every effort. But such precautions having been taken, I see no great difficulty in protecting the house. You may do it as the French do, by iron joists, &c., or in the way used here, and known as Fox and Barrett's plan, or by any way by which the spaces between the iron may safely be filled in with good plaster or other concrete; and doubtless, with long bearings, iron must be used in some way, nor is its use objectionable where such low temperatures only are to be looked for, and when protected by a plastered ceiling. But, in addition to the cost of the iron, it is a material always troublesome to use: one wants to trim a floor, or bevil off a headway, and so on—things done easily enough in wood, but often very difficult or costly with iron; and I really do not see that it possesses any advantage over wood, when the latter is equally protected by plaster and concrete with the iron.

This protection may be had in several ways. We may adopt the ordinary French plan, as described by Mr. Hosking, viz: of having very strong laths, filling in the ceiling from above, on to a temporary scaffolding, (instead of pressing it upwards, as with us,) and filling in the whole space between the joists with rubble, so as to form a solid flooring. But this plan has the disadvantage, that the whole weight of the ceiling is carried by the nails of the lathing, and any carelessness or want of skill (not unlikely to be experienced in the use of a method new to our workmen) may produce fatal results. With iron joists the laths rest on the flanges, and iron has thus so far an advantage over wood. But I feel quite satisfied that strong, thick pugging would be almost equally efficacious if the sound boards be split in narrow widths, and the soffits plastered so as to form one mass with the pugging over, thus leaving but a very small part of the bottom of the joists exposed. This would be still further protected by the key of the plaster ceiling, if the sound boarding could be brought so low as that the key of the plaster ceiling would unite with that of the pugging. The difficulty in the way is that the fillets must then be brought so low (close to the soffit of the joists) as to render the latter liable to be split and weakened by the fillet nails. An ingenious plan of obviating this was used by Mr. Marrable at the Board of Works offices in Spring-gardens, viz: cutting the joists in a wedge form, (two out of one, so as not to waste the timber,) so that the concrete filling-in used there had, when dry, all the properties of an arch, and pressed against the joists as its abutment, instead of bearing with its full weight upon the fillets. The floor over being tongued, the draft will be stopped, I fully believe, almost as well as by Hartley's plates. I have recently seen a case of a fire in a warehouse, where the heat was so severe that the wrought iron doors were bent so as to be useless, and yet the wooden-tongued floor had completely prevented the flames from spreading downwards.

Another way of forming floors has been much used in the Midland counties, and is well known as Dennett's, being formed of concrete,

to which I have already favorably alluded. The patentees claim for it greater lightness, solidity, and cheapness than four and a half inch brick arching, and I fully believe it has them. But the absence of lateral pressure is also claimed; and I cannot at all understand this. If the arch form be of any use, it can certainly only be, as far as I can see, by a pressure on the abutments. If the material itself give the strength, and the abutments are not strained, the floor may as well be laid flat. With good abutments there is much to recommend this plan, as it will, I think, be efficacious, and the arched form worked out of the actual solid, and not by plaster bracketing, (as dangerous in case of fire as false in construction,) is very much the thing we want, to help us to variety in the section of our ceilings. If, however, the bearings are of iron, Dennett's plan is open to all the objections to which the iron itself is liable. There are also in the South Kensington Museum a great many full-sized models of plans for fire-proof construction, but all, I think, without exception, depend upon iron girders for their bearings or abutments, or such a condition must be fatal to their use. Of another plan, suggested by Alderman Waterlow, where the strength of the floor depends upon the system of iron rods, built into, and therefore protected by, the concrete, I speak with reservation, as the system has never yet been tested by an actual fire. But in ordinary houses the heat is so comparatively slight, and the force of the flames so taken off generally by the stairs as an outlet, that there seems to be little difficulty in protecting the floor, whether by this or by other methods. It is in the construction of warehouses and other large places, wherein large masses of combustible matter are stored, that we meet with the really great difficulty, for we have to encounter there an excess of temperature unknown elsewhere. Of all the plans that have been tried for the protection of these places, I suppose that the one of brick arches carried by cast iron girders is that most commonly used. Doubtless such a floor would be of use in order to prevent fire spreading downwards. But the iron-lined ceilings as used at Nottingham and elsewhere, where the floors are inflammable, owing to the oil dropping from the machinery, or even an iron-tongued floor, where no such extra risk exists, would go far towards answering the same purpose, whilst what I have already said will show how little dependence can be placed upon the iron if the heat can only get at it. Even if the girders themselves could resist the heat and the water, the arches would at once be deprived of the tie which forms their security, by the bending of the tie rods. For I never remember to have seen a case in which rods, used for whatever purpose, were not found so bent after a fire as to show that their strength as ties are gone. It so happens, too, that the form of the iron girder, often adopted as being the strongest in section, viz: that of the reversed ∇ , is really the weakest in case of fire, as the latter has free access to it in every part, whereas, the only chance of a girder being saved is the smallness of its section exposed to the fire.

The system of girders or joists filled in with plaster or concrete is much better than the last, as no tie is required, and, doubtless, in small

cases they may be useful. But I have seen them often tested in large fires, and I remember no instance in which they have there formed an effectual stop. (I am now, of course, speaking of warehouses, or such buildings, and not private houses.) I may again bring forward the wrought iron girders shown on the drawings as a case in point, for these formed portions of a floor which had been filled with concrete 18 inches thick. But the ceiling had been formed of boarding only, the soffits of the girders were exposed to the direct action of the fire, and the greater part of the building destroyed. There is, however, always a difficulty in these cases in determining whether the actual cause of the failure was the iron columns or the girders which they support; for if the columns fail, the bearings of the girders fail also, and the girders must bend or break with the heat and weight. In one remarkable case, where the columns had not been injured, the system had apparently succeeded, the fire having begun on an upper story, and failed at first to work down through the concrete floor. But, some hours after it was supposed to have been subdued, it burst out on the lower story, having apparently sent a stream of heated air through some crack in the concrete, and the whole building was then soon utterly wrecked. This building offered a curious instance in another way of the danger of iron construction. It was circular in plan, the girders radiating to the outer walls from a circular framing in the centre. The ironwork got heated, expanded, and so injured the walls that nearly the whole had to be rebuilt; whereas, I feel quite satisfied that all would have been saved had the girders been of wood. A curious instance of the danger of iron is given in the drawing of brick arches, being a section of part of a building very much injured by fire some years since. The fire broke out on the story covered with this arched construction assumed to be fire-proof. All the arches rested on cast iron girders, except the arch next to the wall, the girder adjoining which turned out to be of wood, put in either by accident, or perhaps as a piece of scamping work. It is the only case of the sort that I remember. The lower surface was exposed in precisely the same way and to precisely the same extent as that of each of the iron girders. The fire was one of the fiercest that I ever remember, and burnt into the brick of the wall, directly under the wood, to a depth of nearly an inch, that having been clearly the hottest part. Yet every iron girder broke in half, throwing down the iron arches which they bore, whilst the wooden one remained to the last, with no more injury than its being turned into charcoal for an inch or so in depth. But I must ask you to consider this question as to wood a little further.

If we examine how buildings built of wood give way, we shall find that, as a general rule, they are constructed with long girders of fir, supported on posts or columns, also of fir, connected together only by the thin joists which carry the deal flooring. These latter, unprotected by ceilings, and seldom even by tonguing, are burnt rapidly away, the heavy timbers, thus left without connexions to steady them, sway over with their weight, fall into the burning ruins, and add to

the fire. Now, if these heavy timbers and posts were of the hard wood which was used of old, and if the space between the joists were filled in solidly with such material as the pugging which Lord Stanhope used, we should have a flooring of much greater value in time of fire than any I know, short of real arches on real brick piers. I do not say that it will be depended upon to stop a fire if once it got ahead. Nothing but arches or piers will do that, unless you divide your warehouses with upright walls, so as to lessen the mass of fire; nor do I contend that there is not a great disadvantage in the use of timber, from its certainty to increase the body of fire if the stairs, for instance, fairly ignite, or the floors give way. But I *do* say, that the danger from the risk of sudden failure in the iron more than counterbalances this; and that if stairs, and floors, and columns were made as I have alluded to, they would offer such chances of delay as might be of the utmost use in preventing loss; and I know well that the men in the brigade would feel themselves secure with such construction, and fearlessly work to save it; whereas, even Captain Shaw himself would hesitate to lead, or the most daring of his men to follow him, into a building, when they know that the lives of all within it depended upon a frame of iron.

I must offer a few words as to *roofs*. The objections that I have elsewhere offered to the use of iron do not apply here, and it is probably the best material to be used. But I must venture to give a caution that battens must be used in the covering, and not boarding, as the fire runs along the latter with great rapidity. I must also notice another practical point recently brought under my notice by Captain Shaw, and which had quite escaped me, viz: that when cisterns are provided against the risk of fire, they should be at a considerable height, as it takes a pressure of 15 feet of water to open the firemen's hose.

I now come to the last part of my subject, and perhaps the most important of any, viz: the stairs. The example I have selected is one of melancholy interest, as it was connected with the deaths of three persons; but the construction of the staircase was of so uncommon a character, as to make it an unusually good case to which to refer. It had walls on three sides, but on the fourth only a thick quarter partition, not brick-nogged, but lathed and plastered as usual. The steps were of good sound Portland, with one end pinned well into the side of the wall, and secured into the wooden partition by strong cross-pieces of wood framed with the uprights. The landings were formed of wooden joists, with plaster ceilings. The fire broke out in the basement story, and could have been of no very great intensity, as the ceiling over was not at all burnt through, and all that there was to feed the fire was the kitchen floor, fittings, and one cross partition. It passed through the door on to the stairs, swept up the stairs, was stopped by a lath and plaster ceiling at top, and rushed out by a window close under it. All the doors of the various rooms leading on to the stairs were shut, so that no damage was done to any of the rooms except by smoke and water. Now, this is a good illustration of the

effect of the first sudden burst of flame, for there was nothing to burn or add to the fire on the staircase, and the only heat was from the rush of flame; yet, before any of the engines began to play, the staircase broke down from the top, and crashed down the whole underneath, leaving the ends projecting from the walls and wooden partitions, which latter held the stair-ends as firmly as the walls did. I was, at first, quite puzzled to account for this. At length I found that a large cistern was on the upper story, full charged at the time of the fire; that a hole had been burnt through the service-pipe from it, directly over the top steps, upon which, thereupon, the whole weight of cold water had come down suddenly, in their heated state. These had snapped off and broken the rest (rendered brittle by heat)-in falling. I have since seen another stone staircase, of similar construction, broken down from apparently the same cause, and others would, of course, follow in the same way directly the engines played upon them. But the fact to which I wish to draw your attention more particularly is that the only parts of the whole staircase which remained secure were the wooden landings, protected only by the plaster ceilings; and that, while every part of the fire-proof construction was utterly destroyed, I took my observations in complete security on these said landings, which remained to the last uninjured.

As a practical result I may, however, say generally that, if the stairs be supported at each end, as they were in the old geometrical and other staircases, it matters very little what their construction may be, as they would be pretty safe any way. For you will find that the way in which a staircase of stone is destroyed, is by the fire rushing up the central well-hole and heating the outer ends to excess. The steps thus become excessively brittle, and snap off at once whenever any sudden weight or change of temperature is brought upon them. With wooden stairs the case is different; they are seldom set fire to from underneath, as the plaster ceilings invariably protect them, unless the plastering is very bad. But the outer string exposed to the full force of the flame catches fire; the flame spreads thence to the riser and the tread, gets thus *behind* the plastering, and the stairs are then destroyed. The present fashion of cut-string is a wonderful help to fire, as it gets at once, without a step, from the outer string to the treads and risers, and it would be no slight step towards safety if the present fashion were discarded in favor of the old massive solid strings and newels. If these were reused, and the stairs made solid with plaster, on some plan like the French, there can be no question whatever that wooden stairs would be something very nearly fire-proof. I ought to refer here to one fine example of a different construction—that of old Rochester castle—the old staircases whereof are formed of concrete, bedded on wooden templates, the marks of which remain now as perfect as the day on which they were laid; and I believe that these old stairs would resist now the trial of fire as they have that of time and weather for some five centuries.

Telemeters, or Instruments for Measuring Distances.

By the late ARCHIBALD H. BELL, M. A.

From the London Mechanics' Magazine, November, 1865.

It is surprising that, notwithstanding the great development during the last few years of the science of gunnery, and the perfection to which guns and projectiles have been brought, one of the most important problems connected with the subject has not as yet received the attention which it obviously deserves, and still awaits satisfactory solution. I allude to the problem of determining the distance of objects. To judge distances accurately and with rapidity has at all times been of very great importance to artillerymen; but since the introduction of rifled ordnance this importance has incalculably increased. We have now guns capable of doing fearful execution at a distance of two miles and a half (4400 yards)—guns capable of efficiently throwing projectiles to a greater range than that at which the Americans boast to have shelled the forts and city of Charleston. The promptitude and certainty with which bodies of men and ships of war are now moved add greatly to the importance of this subject. Powerful steamers, for bombardment or for transport, can be brought into action at the rate of fourteen knots an hour, and be withdrawn as rapidly—a pace far exceeding that of the best appointed four-in-hand coach, or a troop of horse artillery at full gallop. The distance of such a vessel from a battery might vary as much as 100 yards in fifteen seconds, or a quarter of a mile in little more than one minute. Of what avail, then, is the beautifully rifled gun, the accurately fitting projectile, the nicely fixed tangent scale with its verniers, if the true range cannot be determined correctly and instantaneously? What advantage is there in a good direction, rapidity of fire, and penetrating power, if the gun be laid on a point 100 yards or 200 yards beyond or short of the object aimed at? To draw increased attention to this subject is the aim of the following remarks: “*Utila deliberare, mora utilissima est,*” and if this end shall in any degree be attained, it is to be hoped that the service will at length obtain what at present it so urgently requires.

We want the power to determine distances up to two miles and a half with great rapidity, and with sufficient accuracy to enable us to strike such an object as a battalion in column, or a ship of war. By practice the eye may be trained to estimate distances under half a mile with fair precision. At Hythe, the principal school of musketry, this practice is made of prominent importance, and it is found that the average men of a well-drilled class do not err in judging distances of half a mile and under by more than one-tenth of the distance. But it may be asserted, absolutely, that no man can arrogate to himself the power of judging distances of a mile and upwards, with the very smallest degree of certainty; and we therefore require to seek for some kind of instrument for the purpose of obtaining this power. The difficulty to be contended with here is, that no definite space of time, not even one minute, can be allowed for adjusting an instrument, or for

calculation; and thence arises the danger that the most perfectly-contrived instrument may be imperfectly used in the hurry and excitement of action. The requirements of such an instrument for military use are, therefore, 1. That it shall be of simple construction; 2. That it shall be capable of being used with rapidity, and shall show the result at a glance; 3. That any error of adjustment shall be easily recognizable, and readily admit of rectification.

In order to make our professional wants as clear and simple as possible, I classify the various circumstances under which we have to estimate distances as follows: 1. Horse and field artillery require to ascertain the distances of objects over land, whatever may be the features and elevations of the ground, and frequently without much topographical knowledge of the surrounding country. 2. Garrison artillery also require to estimate distances over land, but with the advantage of a perfect acquaintance with the localities and landmarks. 3. We require likewise to estimate distances over water, from forts and batteries on the sea-shore, whether *a fleur d'eau*, or in elevated positions. 4. We require to estimate distances on board ship, where not only the object but also the observer may be in motion. With regard to these four cases, it may be remarked, that it is perhaps of the least relative importance for horse and field artillery to possess instruments for measuring distances. Our magnificent mounted artillery come so rapidly into action that one or two trial shots could probably be always fired before any satisfactory observation could be taken with an instrument; and the shot thus thrown away are not of the same value as the ponderous projectiles of modern garrison and naval artillery. Even in the case of garrison artillery, it may be argued that an instrument is not of vital importance, for the reason to which I alluded above, that, whether the battery be in our own fortifications (a battery of defence), or form part of a siege attack (a battery of offence), the ground in front is usually so studied and planned out that the ranges of all the remarkable objects in sight are well known, and little more information is required of the distance of any object, whether stationary or in motion.

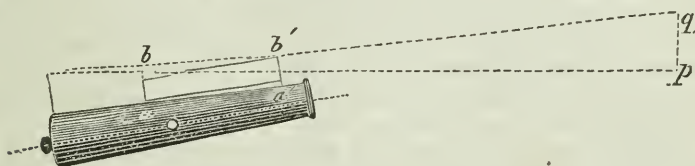
But it must be allowed by every one that it is of the very highest importance that we should possess instruments to enable us to determine distances over the sea from shore batteries. The guns used here are usually of the heaviest nature, throwing the most costly projectiles, and requiring very large charges of gunpowder; they are of necessity slow to load and to manœuvre, and the objects fired at are oftentimes in rapid motion. Trial shots would here be of little use, as there remains nothing to guide the eye to the spot where the last shot struck. In these cases, too, time is everything; the tremendous blow must be struck at one particular moment, or the opportunity may never recur. Consider, for example, the forts at the mouth of a harbor, (at the passage of the Needles, or the much-discussed forts at Spithead,) if the very first round fail to crush a hostile vessel advancing at full speed, her escape is certain; and the battery, placed there solely for the purpose of stopping her, has been merely money thrown away.

The fourth requirement is one of the navy rather than of our own profession, but it is of equal public importance; and though there are many difficulties in this form of the problem, there is every reason to believe its solution to be quite practicable, and that it will some day be effected. It may be that a distinct form of instrument is required for each of these four cases, and for this reason I have kept them separate, as failure is often caused by an attempt to achieve a too comprehensive success. By considering each of these cases by itself and in detail, we may hope to hit upon some good means of attaining our particular object.

Among the most beautiful of the instruments hitherto produced for the purpose of measuring distances, may be mentioned the inventions of Cavallo, of Rochan, of Professor Piazzzi Smyth, Astronomer Royal at Edinburgh, of Lieutenant-Colonel Clerk, of our own Regiment; and of M. Otto Struve, Astronomer Royal at St. Petersburg. None of these have yet been introduced into our service—“*Certant, et adhuc sub judice lis est.*” I should, however, mention that M. Otto Struve’s instrument was some years ago introduced into the Russian service, and is now in use at Cronstadt. Without now entering into the details of these inventions, I may remark that there is one fundamental principle upon which they all depend, and upon which all our efforts to estimate distance must be built, viz: that knowing the base of an isosceles (or of a right-angled) triangle, we can ascertain the height by measuring the vertical angle. We unconsciously put this principle into practice at every moment of the day,—the distance between the pupils of our eyes being the base of the triangle, of which the sides are the rays of light passing from any point of the object looked at to our two eyes. The old experiment of trying to snuff a candle with one eye shut, shows us that we cannot appreciate distance with one eye with the precision and promptness we can attain with both eyes open. When using one eye only, we are instinctively forced to reverse the mode of applying the principle, and to take as our base some known or supposed dimension of the object, and to estimate the angle formed by the rays of light passing to the pupil of our one eye from the two extremities of this distant base. It is in this reversed or one-eyed manner that the instruments of Cavallo and Rochan are constructed; the actual size of some distant object, such as the height of a man, is assumed as known, and the distance is estimated by noting the number of graduations which the object subtends on a micrometer in the eye-piece of a telescope. Now, we might possibly obtain satisfactory results from these instruments, if the enemy’s army could be forced to pass a night in our own bed of Procrustes; but as men vary in size by as much as *one-seventh* of their height, and as their apparent height varies considerably by the different national and regimental forms of head-gear, thickness of boots, and other circumstances, it can easily be conceived that the error with these instruments may be very great, probably as much as *one-tenth* of the whole distance, or 176 yards in one mile, quite enough to make artillery practice very harmless.

A method of estimating distances without any special instrument, by the assumed size of an object, (such as the average height of a man,) has been lately proposed by J. M. de Tilly, (Sous-lieutenant de l'Artillerie Belge,) an account of which may be found in the *Revue de Technologie Militaire*, tome iii. He proposes to have upon the chase of a gun, (see Fig. 1,) and near to the muzzle, a foresight $a' b'$, capable of sliding backwards and forwards, parallel to the axis of the piece. The gun having been laid upon the bottom p of the object $p q$, while the foresight is in its position $a b$ nearest to the breech, the foresight is moved towards the muzzle until its upper edge is just in line with the top of q of the object; the space $a a'$, over which the foresight has

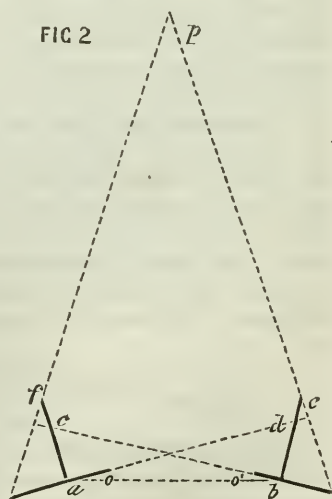
Fig. 1.



passed is noted, and the distance of the object calculated, or the distances may be graduated upon the chase of the gun. With reference to this method of estimating distances, we may observe that it has all the disadvantages of Cavallo and Rochan's micrometers, with the additional objection of impeding the proper use of a gun at the very time when probably it is most needed.

We may further remark that, practically, this means cannot be used for distances over 1200 metres, and that at that range the error may amount to as much as 89 metres. M. de Tilly also proposes a method of measuring distances by means of two guns and a measured base, (see Fig. 2.) The two guns, $a f$ and $b e$, are placed about twenty yards apart, the wheels covering each other; the right-hand gun is then laid upon the object with 10° right deflection; the left-hand gun is laid upon the same object with 10° left deflection; the exact distance $a b$ between the tangent scales of the two guns is then measured with a tape or chain. Each gun is provided with a sliding foresight c and d similar to that above-mentioned; the tangent scale of each is also furnished with a horizontal arm $a o$ and $b o$ perpendicular to the axis of the gun. The foresights c and d are now moved until they are in the prolongation of these horizontal arms of the alternate guns, and the distances from the tangent scales to the foresights are

FIG 2



measured, or they may be graduated upon the guns. From these data, viz: 1st, the distance apart of the guns; 2d, the angle of deflection at which they are laid; 3d, the distances from the tangent scales to the sliding foresights—the distance of the object may be calculated, or a set of tables may be previously calculated of the distances corresponding to all possible value of the variables. The material required to carry this theory into practice are, then—1st, two guns, with special arms to the tangent scales, and a movable foresight to each; 2d, a measuring tape or chain; 3d, a set of intricate tabulated calculations; and, lastly, four men to take the observations and measure the base. With all this, the errors which may arise in such observations are three-fold: 1, a possible error in the positions of the foresights; 2, in the measurement from gun to gun; and 3, in the laying of the guns. Combining these together, M. de Tilly acknowledges that, in a distance of 1500 metres, an error might occur of 117 metres—in a distance of 2500, an error of 273 metres. This being the case, however much we may admire M. de Tilly's ingenuity, we cannot consider his suggestions to be of practical value.

The other instruments to which I alluded above, viz: those of Professor Piazzi Smyth, Lieutenant-Colonel Clerk, R. A., and of M. Otto Struve, are designed on the principle of binocular vision, consisting, in fact, of two telescopes, with which simultaneous observations are taken at the opposite extremities of a fixed base line. They differ from each other only in the details of their construction. The following is a brief description of Lieutenant-Colonel Clerk's instrument: The rays of light from the object are intercepted at each extremity of a tube by an object-glass, whose focal length slightly exceeds the half-length of the instrument. The pencils of rays are reflected by mirrors, along the tube to the centre, where they are again received by other reflectors, so placed as to throw the two images into the focus of a common eye-piece, so that they can be seen simultaneously by one observer. In the focus of the eye-piece are two vertical hairs, one fixed, the other movable by means of a micrometer screw, by which the interval between the two images can be measured with great delicacy. The distance of the objects is estimated, as I have before stated, by the angle subtended at the object by the rays of light passing from any point in the object to the two object glasses of the instrument. This angle is obtained from the following equation:

$$\text{Sine } \theta = \frac{\text{distance of movable hair from its position when instrument is set to infinity}}{\text{focal length of object glass.}}$$

These instruments are exceedingly beautiful, both in design and in construction; but they are of very delicate construction, and great care and nicety are required to obtain trustworthy observations. They can, therefore, only be put into the hands of an expert observer. For comparatively short distances they are exceedingly correct, distances of two and three hundred yards being measured to within a few inches, which is greater accuracy than is usually attained by ordi-

nary chaining. Such instruments are therefore likely to be of great value in land surveying, and they have, I believe, been applied to that purpose in Russia. But it still remains to be decided whether observations depending on twice-reflected images are to be relied on for the long ranges, and under the ordinary circumstances of military service. At great distances the twice-reflected images lose much of their sharpness of outline, and the two images being in very close proximity, if not overlapping each other, the greatest nicety is required to measure the interval between them. Strong light—not always attainable in our climate—is also indispensable, so much being lost in the double reflection. A very great source of error, against which it is difficult to guard, is any unequal expansion in the tube of this class of instrument from alteration in the temperature, or the direct influence of the sun, any amount of curvature, however minute, altering the angles of the mirrors and causing a very considerable error. If, however, an observation can be taken of some object at a known distance, either immediately before or immediately after making the required observation, the necessary amount of correction may be ascertained. But this entails a loss of time, and is not in all cases practicable.

Professor Piazzzi Smyth and M. Otto Struve each constructed instruments upon a similar plan to this, and, singularly enough, though working independently, they both selected five feet as the length of their base. Lieutenant-Colonel Clerk's first instrument had a base of two feet. Mr. Adie, instrument maker in the Strand, exhibited a similar instrument at the Aldershot, in May, 1864,* having a base of 18 inches; it was stated to be efficient to 1500 yards, and its price was £8 8s. With an instrument 3 feet long, costing £12 12s., Mr. Adie expects to be able to measure distances up to 3000 yards; and with an instrument carrying a base of 6 feet, he is confident of securing the fairly accurate measurement of distances of seven or eight miles. This anticipation may be accepted *quantum valeat*, as it has not been established by experience, and certainly strikes one as chimerical. A very beautiful instrument of Lieutenant-Colonel Clerk's design, having a base of 73·6 ins., is now under trial, and therefore until this, as well as Mr. Adie's improvements, have been fully tested, it may be considered premature to express any definite opinion concerning the utmost capabilities of this class of instruments.

(To be continued.)

Strength of Timber Beams. By WYATT PAPWORTH.

From the London Builder, No. 1202.

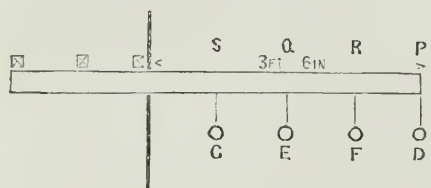
Herewith I forward, for insertion in the *Builder*, the results of some few experiments recently made by me upon the strength of beams, to

* Professor Smyth's instrument was constructed in 1855, and Lieutenant-Colonel Clerk's in 1858. Mr. Adie patented his instrument on 10th February, 1860, and registered improvements on 4th March, 1863. Mr. Adie employs prisms for reflecting, instead of mirrors; and, in place of having hairs in the eye-piece, he has one of the object-glasses in a movable frame, by which means the two images are made to coincide, and the angle of the object-glass is then noted.

find a *practical* reply to the question put by "A Student," in page 878 of last year's volume.

A piece of yellow fir, 7 feet 6 inches in length, and 2 inches square, was placed to represent a beam with its ends loose, having a clear span of 7 feet between the supports. Two weights, $\frac{3}{4}$ -cwt. each, were suspended as close as possible at the middle of the length. The deflection just exceeded an inch, being $\frac{3}{20}$. I call this experiment A. When the two $\frac{3}{4}$ -cwt. were placed half-way between the middle and one of the supports, the beam deflected at that point $\frac{1}{20}$; this I call B. When but one of the $\frac{3}{4}$ -cwt. was placed there, it deflected at that point only $\frac{7}{20}$; this I call C.

The piece of wood was then shifted so as to project as an arm for half its length, or 3 feet 6 inches only. A rough diagram will explain the succeeding operations.



One $\frac{3}{4}$ -cwt. was placed at D, or *half the weight* applied in the case of A. The beam instantly deflected $\frac{4}{20}$, or just upon *double* of A. But noticing that the fixed half of the beam was being unduly strained, I had the arm shifted

to a better bearing, and secured still more firmly. On being tested again with the same weight, it deflected $\frac{3}{20}$, or *almost three-quarters more* than that of the beam A.

Applying the same weight at E, that is, in the middle of the length of the arm, the arm deflected at that point $\frac{12 \cdot 5}{20}$. With the like weight

placed at F, the deflection at that point was $\frac{21 \cdot 5}{20}$. With the same weight at G, the deflection at that point was $\frac{5}{20}$.

Again placed loose on its supports, 7 feet apart, the beam was loaded at two points dividing the length into three equal parts; the deflection in the middle of the length of the beam was $\frac{1}{20}$, with one $\frac{1}{2}$ -cwt. at each point (II). But with the $\frac{3}{4}$ -cwt. at each point, the deflection was $\frac{1}{20}$ (I). The beam was, as a last trial, again proved with the weights as in A, with the same result as at first, indicating that the elasticity had not been affected, and that no deduction for loss of power is to be made from the various results.

The two main results, then, are—1. That the beam deflected $\frac{3}{20}$ with $1\frac{1}{2}$ cwt.; and 2, that the arm of half the length deflected $\frac{3}{20}$ with $\frac{3}{4}$ -cwt., or equal to 1·8 inch.

Not having Fenwick's work mentioned by Mr. Tarn, (page 895 of last year's volume,) I cannot work out the formula given by him, as the letters E and I are not explained; but Gregory's "Mechanics for

Practical Men," edit. 1862, page 388, gives the formula
$$\frac{432 \cdot l^3 \cdot w}{m \cdot b \cdot d^3} = D.$$
 Working this out in the case of the beam in question, I obtain

the formula in figures $\left\{ \frac{432 \times 343 \text{ feet} \times 168 \text{ lbs.}}{2,016,000 \text{ lbs.} \times 2 \text{ inches} \times 8 \text{ inches}} = D, \text{ or } \right.$
 (red or yellow fir)

deflection in inches; that is, deflection = .77175. Or, if 1,460,000 for m be taken, as given as the lowest quantity for red pine, by Rankine, in "Civil Engineering," the result is 1.065, a quantity not differing so very much from the experiment, which showed a full inch.

Now, where does science teach me the amount of the deflection of the arm? Barlow said, until 1851, that it would be *double* the deflection of the beam: then $.77175 \times 2 = 1.54350$; and $1.065 \times 2 = 2.130$, neither of which results is very satisfactory with the actual fact of 1.8 inches. The new edition (1851) of Barlow says, that the deflection of the arm will be *equal* to that of the beam; but the experiment clearly contradicts this authority. I am, therefore, inclined to put entire faith in the result given from numerous experiments made with perfect apparatus by Barlow, which does not seem to have been affected by other researches during his lifetime, and to take the *double* as the safest guide.

Not being thoroughly satisfied with experimenting with one piece of timber, I have tried another, of a different size and somewhat different material, the opportunity and material for both having been obligingly furnished by Mr. Henry Burton, on his premises at Aldersgate Street. This second beam was provided as memel, 10 feet in length, 2 inches wide, and 3 inches deep, being slightly more than the proportion of 5 : 7,—that of the strongest form for a beam. The clear span was 9 feet; and, with the ends loose as before, the beam deflected $\frac{1}{20}$ of an inch with $1\frac{1}{2}$ cwt. in the middle (L). With a $\frac{3}{4}$ -cwt. placed at one-third of the length from each support, the deflection in the middle was $\frac{7.5}{20}$ (M). With $1\frac{1}{2}$ cwt. placed at one-third from one support the deflection was, at that point, $\frac{7}{20}$ (N); while at the middle the deflection was $\frac{8}{20}$ (O).

With regard to the arm, one part, 5 feet 6 inches long, was securely fixed, when the projecting portion, 4 feet 6 inches, deflected, with $\frac{3}{4}$ -cwt. at P, (as in above diagram,) $\frac{23.5}{20}$ inches, or just about three-quarters $\left(= \frac{23.75}{20} \right)$ more than that of the beam L. The same weight

at Q gave a deflection of $\frac{5.25}{20}$ at that point; at R, of $\frac{1.2}{20}$ at that point; at, S of $\frac{2.33}{20}$ at that point.

Two main results of this experiment, then, are—1. That the beam deflected $\frac{1}{20}$ with $1\frac{1}{2}$ cwt.; and 2, that the arm of half the length deflected $\frac{23.5}{20}$ with $\frac{3}{4}$ cwt. or 1.17 inch.

Working out the deflection L, with the formula as above given, we have $\frac{432 \times 729 \text{ feet} \times 168 \text{ lbs.}}{1,460,000 \text{ lbs.} \times 2 \text{ inches} \times 27 \text{ inches}} = \text{deflection or } .67, \text{ and}$

the actual experiment gives .65; but it must be noticed that I have again used the lowest modulus of elasticity for red pine, not memel, as given by Rankine. Using the figures 1,957,750, as given by Tredgold for memel, the resulting deflection is .500. The inference might be drawn that the piece of wood was a weak specimen of memel. I was glad to find that the two sets of experiments agree. But if any of your readers think that I could have carried them further, possibly they will spend an hour or two on an improved series, and communicate the result. But perhaps this *practical* reply will be found a satisfactory answer to the question so usefully propounded by "A Student," who will now probably be led to doubt the accuracy of the "thorough *mathematical* investigation" on which Fenwick, according to Mr. Tarn, arrived at conformity with the statement of the new edition of Barlow's *Treatise on the Strength of Timber*, 1851, which renders that edition of questionable utility from the necessity for making corresponding alterations in the text. Perhaps, however, some scientific friends may be able to explain wherein lies the difference of the results of the carefully executed experiments with those of the mathematical investigations.

MECHANICS, PHYSICS, AND CHEMISTRY.

From the Journal of the Franklin Institute.

Strength of Cast Iron and Timber Pillars: A series of Tables showing the Breaking Weight of Cast Iron, Dantzic Oak, and Red Deal Pillars. By WM. BRYSON, C. E.

(Continued from Vol. L., page 187.)

In the September number of this *Journal*, Vol. L., pages 181 to 187, I gave a table of the calculated breaking weights of 288 hollow uniform cylindrical pillars of cast iron, both ends being flat and firmly fixed; together with the calculated values of w , c , and Y , from the formulas of the late Mr. Hodgkinson,

$$w = 46.65 \frac{D^{3.55} - d^{3.55}}{L^{1.7}},$$

$$Y = \frac{w c}{w + \frac{3}{4} c}.$$

A communication "On the Strength of Cast Iron Pillars," by Mr. G. P. Randall, dated from Chicago, August 24, 1860, was published in the *Architects' and Mechanics' Journal*, September 15, 1860, (Vol. II.,) which does not appear to me calculated to be "a valuable table for reference for builders, foundrymen, and others." On the contrary, it is more likely to mislead any person that would be simple enough to rely upon it for accuracy in all its detail, without first making his own calculations, although I do not suppose that any architect or foundryman of experience would. The formula given by Mr. Hodgkinson, and to which Mr. Randall refers, is decidedly intended for

TABLE showing the weight of "perfect safety," in tons, according to Mr. Randall's instructions, being one-third of the breaking weights as given in his Table.

Diameter of column in inches.	Thickness of metal, Inch.	LENGTH OF THE COLUMN IN FEET.																	
		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
3	$\frac{1}{2}$	17	14	11	10	8	7	6	6	5	3	4	4	3	3	3	2	2	2
4	$\frac{1}{2}$	39	32	27	23	20	17	15	13	12	11	10	9	8	7	7	6	6	5
5	$\frac{1}{2}$	75	68	50	43	38	33	29	25	23	21	19	17	15	14	13	12	11	10
6	$\frac{1}{2}$	125	102	85	72	63	54	48	43	38	34	31	28	26	24	22	20	19	18
7	$\frac{3}{4}$	260	213	178	151	131	114	100	89	80	72	65	60	55	50	46	43	40	37
8	$\frac{3}{4}$	380	311	260	222	191	167	147	130	117	105	95	87	80	73	68	63	58	55
9	$\frac{3}{4}$	527	431	361	307	265	231	203	181	162	146	132	121	111	102	94	87	81	76
10	$\frac{3}{4}$	705	577	482	410	355	309	272	242	217	196	177	161	148	136	126	117	109	102
11	1	1140	940	787	669	579	504	444	395	354	319	289	264	242	223	206	191	177	165
12	1	1464	1198	1002	852	737	642	569	503	450	400	369	336	308	284	262	243	226	211
13	1	1826	1495	1250	1063	919	801	705	627	562	507	460	419	384	354	327	303	280	263
14	1	2238	1832	1532	1303	1127	995	864	769	689	616	564	514	471	434	401	371	346	322
15	$1\frac{1}{4}$	3233	2646	2213	1882	1628	1418	1249	1111	995	897	814	743	681	627	579	537	499	460
16	$1\frac{1}{4}$	3865	3162	2653	2251	1947	1695	1493	1328	1190	1073	974	888	814	749	692	642	597	556
17	$1\frac{1}{4}$	4565	3737	3125	2658	2299	2002	1773	1569	1405	1268	1150	1049	962	885	818	758	705	658
18	$1\frac{1}{4}$	5339	4371	3656	3100	2689	2342	2062	1836	1644	1483	1345	1227	1123	1035	957	887	825	769

TABLE from my calculations, showing the assumed safe weight, in tons, being one-fourth of the computed breaking weight from Mr. Hodgkinson's formulas as given in my tables for Hollow Uniform Cylindrical Pillars of Cast Iron, both ends flat and firmly fixed. See pages 181 to 187, Vol. I., of this Journal.

Diameter of the pillar in inches.		Thickness of metal, in inches.	LENGTH OF THE PILLAR IN FEET.																	
			8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
3	$\frac{1}{2}$		12-60	10-49	8-77	7-45	6-43	5-61	4-93	4-4	3-94	3-55	3-22	2-94	2-69	2-48	2-29	2-12	1-98	1-84
4	$\frac{1}{2}$		25-01	21-95	19-39	17-23	14-98	13-07	11-52	10-25	9-18	8-28	7-52	6-85	6-28	5-78	5-34	4-95	4-61	4-30
5	$\frac{1}{2}$		40-23	35-96	32-26	29-05	26-27	23-85	21-73	19-35	17-34	15-64	14-19	12-95	11-87	10-92	10-09	9-36	8-70	8-12
6	$\frac{1}{2}$		57-31	52-02	47-30	43-11	39-39	36-09	33-15	30-54	28-22	26-03	23-62	21-54	19-74	18-17	16-79	15-57	14-78	13-51
7	$\frac{3}{4}$		106-64	97-77	89-71	82-43	75-86	69-95	64-64	59-86	55-55	51-67	48-16	44-95	41-2	37-92	35-03	32-48	30-22	28-19
8	$\frac{3}{4}$		134-93	125-08	115-93	107-5	99-77	92-70	86-25	80-37	75-01	70-12	65-67	61-6	57-88	54-47	51-03	47-92	44-02	41-06
9	$\frac{3}{4}$		164-04	153-46	143-46	134-08	125-35	117-32	109-83	102-88	96-52	90-67	85-28	80-31	75-74	71-52	67-63	64-03	60-7	57-01
10	$\frac{3}{4}$		193-66	182-55	171-88	161-75	152-19	143-21	134-82	127	119-72	112-95	106-67	100-84	95-43	90-41	85-74	81-4	77-38	73-61
11	1		288-92	273-14	258-42	244-31	230-87	218-15	206-16	194-9	184-34	174-47	165-26	156-65	148-62	141-13	134-14	127-61	121-32	115-83
12	1		328-39	312-83	297-60	282-82	268-61	255-03	242-1	229-86	218-29	207-38	197-12	187-48	178-42	169-92	161-94	154-45	147-48	140-84
13	1		368-6	352-82	337-21	321-93	307-10	292-8	279-09	265-99	253-52	241-69	230-48	219-87	209-80	200-4	191-48	183-07	175-14	167-06
14	1		408-91	392-99	377-13	361-48	346-16	331-29	316-91	303-09	289-84	277-18	265-12	253-64	242-84	232-38	222-58	213-28	204-48	196-15
15	$1\frac{1}{4}$		549-11	529-19	509-22	489-41	469-92	450-89	432-41	414-55	397-35	380-84	365-04	349-04	333-54	321-83	308-78	296-38	284-59	273-4
16	$1\frac{1}{4}$		599-49	579-56	559-45	538-38	519-52	500	480-93	462-30	444-44	427-11	410-44	394-43	379-09	364-41	350-39	337	324-22	312-05
17	$1\frac{1}{4}$		649-82	629-95	609-79	589-55	569-41	549-51	529-96	510-85	492-26	474-22	456-79	439-90	425-77	408-21	393-29	378-98	365-29	352-18
18	$1\frac{1}{4}$		700-11	680-33	660-17	639-84	619-5	599-31	579-38	559-81	540-67	522-02	503-92	486-37	469-42	453-06	437-31	422-16	407-6	393-03

TABLE from my calculations, showing the assumed weight of "perfect safety," in tons, being one-tenth of the computed breaking weight, from Mr. Hodgkinson's formulas as given in my tables for Hollow Uniform Cylindrical Pillars of Cast Iron, both ends being flat and firmly fixed. See pages 181 to 187, Vol. L., of this Journal.

Diameter of the pillar in inches	Thickness of metal in inches	LENGTH OF THE PILLAR IN FEET.																	
		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
3	$\frac{1}{2}$	5.04	4.19	3.6	2.98	2.57	2.24	1.98	1.76	1.57	1.42	1.29	1.17	1.07	0.99	0.91	0.85	0.79	0.73
4	$\frac{1}{2}$	10	8.78	7.75	6.89	5.99	5.23	4.61	4.1	3.67	3.31	3	2.74	2.51	2.31	2.13	1.98	1.84	1.72
6	$\frac{1}{2}$	16.09	14.38	12.9	11.62	10.5	9.64	8.69	7.74	6.93	6.25	5.67	5.18	4.74	4.37	4.03	3.74	3.48	3.24
6	$\frac{1}{2}$	22.02	20.81	18.92	17.21	15.75	14.45	13.26	12.21	11.28	10.41	9.44	8.61	7.89	7.27	6.71	6.22	5.79	5.4
7	$\frac{3}{4}$	42.65	39.11	35.88	32.97	30.34	27.98	25.85	23.94	22.22	20.66	19.26	17.98	16.48	15.16	14.01	12.99	12.08	11.27
8	$\frac{3}{4}$	53.97	50.03	46.37	43	39.9	37.08	34.5	32.14	30	28.05	26.27	24.64	23.15	21.78	20.41	18.92	17.6	16.42
9	$\frac{3}{4}$	65.61	61.38	57.38	53.63	50.14	46.93	43.93	41.15	38.61	36.26	34.11	32.12	30.29	28.61	27.05	25.61	24.28	22.8
10	$\frac{3}{4}$	77.46	73.02	68.75	64.7	60.87	57.28	53.92	50.8	47.88	45.18	42.67	40.33	38.17	36.16	34.29	32.55	30.95	29.44
11	1	113.33	109.25	103.37	97.72	92.34	87.25	82.46	77.96	73.73	69.79	66.1	62.65	59.45	56.45	53.65	51.04	48.61	46.33
12	1	137.35	125.13	119.04	113.13	107.44	102.01	96.84	91.94	87.31	82.95	78.85	74.99	71.36	67.96	64.77	61.78	58.97	56.33
13	1	147.44	141.12	134.88	128.77	122.84	117.12	111.63	106.39	101.41	96.67	92.19	87.95	83.94	80.16	76.69	73.23	70.05	67.06
14	1	163.56	157.19	150.85	144.59	138.46	132.51	126.76	121.23	116.93	112.87	109.04	104.45	97.13	92.95	89.03	85.31	81.79	78.46
15	$1\frac{1}{4}$	219.64	211.67	203.68	195.76	187.97	180.35	172.96	165.82	158.94	152.33	146.01	139.97	134.21	128.73	123.51	118.55	113.83	109.39
16	$1\frac{1}{4}$	239.79	231.82	223.78	215.75	207.8	200	192.37	184.95	177.77	170.84	164.17	157.77	151.63	145.76	140.15	134.8	129.69	124.82
17	$1\frac{1}{4}$	259.93	251.96	243.91	235.82	227.76	219.8	211.98	204.34	196.9	189.68	182.71	175.98	169.5	163.28	157.31	151.59	146.11	140.87
18	$1\frac{1}{4}$	280.04	272.13	264.07	255.93	247.8	239.72	231.75	223.92	216.26	208.8	201.56	194.55	187.76	181.22	174.92	168.86	163.04	157.45

similar pillars, as referred to in his paragraph, namely, 10 feet long, and from $2\frac{1}{2}$ to 4 inches diameter; but Mr. Randall has overlooked this important fact.

It is absurd even to suppose that Mr. Hodgkinson ever intended the formula used by Mr. Randall to apply to the strength of a pillar 18 inches diameter and its height only $5\frac{1}{3}$ times its diameter.

These tables, I presume, will be of some benefit to many persons who are incapable of making calculations of the strength of uniform hollow cylindrical cast iron pillars, and others who, from apparent carelessness or want of information on this important subject, have not set their pillars as they ought to be, and to enable them and all others to guard against failure in future operations. They may also be useful to some architects and civil engineers.

I will take this opportunity of here giving a few extracts, with some alteration, from what I have before given to the public. In how few cases are the iron pillars supporting heavy weights scientifically or correctly erected. Numerous are the instances of the irregularity of the manner in which they are fixed or placed in position; hundreds of them never squared on their ends, or at right angles to the axis of the pillar; many of them with pieces of iron wedges at one corner (when the bases or plinths are square); the other corners, perhaps, on a stone plinth or top of a stone pier, partly dressed with the chisel, and wholly unsupported in the centre. The necessity of squaring the ends perfectly has been shown, by Mr. Hodgkinson's experiments, to be of the utmost importance.

If a cast iron hollow cylindrical pillar, properly squared and fitted on the ends or turned in the lathe, will sustain a breaking weight of 170 tons, and another of the same dimensions, imperfectly set, (or in the usual manner,) will sustain only 50 tons, the loss of strength is quite evident; in the first case, the assumed safe load should not be more than about $42\frac{1}{2}$ tons; and in the second, $12\frac{1}{2}$ tons.

Pillars imperfectly set cause a great loss of material, by not squaring or fitting their ends properly, requiring about four times as much material to be used in their construction than is absolutely necessary; whereas, the cost of fitting them accurately on their ends cannot, in any case, equal the cost of the loss of the material.

On inspection of Mr. Randall's table it will be seen that a hollow cylindrical pillar of cast iron, 8 feet in length or height, 18 inches external diameter, with a thickness of metal of $1\frac{1}{4}$ inches, and whose height is equal to $5\frac{1}{3}$ times its diameter, is calculated to sustain a breaking weight of 16,017 tons. This would be sufficient to sustain a solid pillar of cast iron of $8\frac{1}{2}$ miles high.

Mr. Randall in his table has given the breaking weights of 288 pillars, 76 of which only are correct as regards the breaking weight, being a little more than one-quarter of the whole table. On reference to Mr. Randall's table, any one can perceive, at a glance, its incorrectness; for instance, for a hollow cylindrical pillar, 8 feet long and 17 inches diameter, thickness of metal $1\frac{1}{4}$ inch, he gives the breaking weight at 13,696 tons, and for another of the same length and 18 inches diameter, he gives 16,017 tons, which is an increase of 2321

tons, or enough for the whole pillar to support, being 1621 tons more than the assumed safe load, as will be seen by the result of my calculation given in my tables.

I have seen many pillars of different materials that were bent under a superincumbent weight, and if these had been properly calculated bending should not have taken place. I here instance four cast iron pillars about $12\frac{1}{2}$ feet high and 5 inches external diameter, supporting a cut stone front 20×40 feet; and after the building was erected, I observed that the pillars were deflected about $\frac{1}{2}$ or $\frac{3}{4}$ of an inch in their height, which plainly shows that they are not sufficiently strong for the building; how much more additional weight than the front that they have to support, I am not prepared to say, but one of the pillars being at the angle of a street, has an additional duty to perform in supporting about four feet of the flank wall; these pillars are irregularly fixed, and I doubt not but that they were erected without making any calculation.

Mr. Randall, in his table already referred to, has given the breaking weight of a pillar 8 feet high, 18 inches external diameter, $15\frac{1}{2}$ inches internal diameter, or $1\frac{1}{4}$ inch thickness of metal, calculated at $5\frac{1}{2}$ times its diameter to sustain a weight of 16,017 tons, equal to a solid pillar of the same material and same external diameter of 79,729 cubic feet. Taking the specific gravity of cast iron at 7200 or 450 lbs. to the cubic foot, will give us a solid pillar of the same material, 18 inches diameter, of 45,300 feet high, or about $8\frac{1}{2}$ miles; thus $16,017 \times 2240 = 35,878,080 \div 450$ lbs. in a cubic foot of cast iron = 79,729 cubic feet in 16,017 tons of cast iron, and $79,729 \div 1.76$ foot = the area of the base of 18 inches diameter, is equal to 47,300 lineal feet for the height of the solid cylinder, and $45,300 \div 5280$ feet (the number of feet in a mile) produces 8.57 miles for the height; or, in other words, it will sustain a solid rock or cube of granite whose sides are 60 feet = 216,000 cubic feet.

It will be found by my calculations for the above pillar, that the breaking weight is 2800 tons, which is nearly six times less than Mr. Randall's; the assumed safe weight would be about 700 tons, which is quite enough, in all conscience, to expect it to support. (The assumed weight of perfect safety; 280 tons.) The weight of "perfect safety" of Mr. Randall's would be, according to his instructions, 5239 tons, or about seven and a half times too great for the assumed weight of safety, and twenty times too great for perfect safety.

Solid Uniform Cylindrical Pillars of Red Deal, both ends being flat and firmly fixed.

Length or height of pillar in feet.	Diameter in inches.	Value of w in tons from formula $w = \frac{D^4}{479 L^2}$	Value of c.	Calculated break- ing weight in tons from formulas $w = \frac{D^4}{479 L^2}$ $y = \frac{w c}{w + \frac{3}{4} c}$
8	15	3788.06	519.54	471.11
35	"	197.95	"	175.02

Hollow Uniform Square "Box" Pillars of Red Deal, both ends being flat and firmly fixed.

Length or height of pillar in feet.	External side of the square in inches.	Internal side of the square in inches.	Value of w in tons from formula $w = 7.81 \frac{D^4}{L^3}$	Value of c.	Calculated breaking weight in tons from formulas $w = 7.81 \frac{D^4}{L^3}$ $y = \frac{w c}{w + \frac{3}{4} c}$
6	4	2	52.06	35.28	23.89
7	"	"	38.04	"	20.80
8	"	"	29.28	"	18.53
9	"	"	23.14	"	16.45
10	"	"	18.74	"	14.62
11	"	"	15.49	"	13.02
12	"	"	13.01	"	11.62
13	"	"	11.09	"	10.41
14	"	"	9.56	"	9.36
			Calculated breaking weight from the above formula.		
15	"	"	8.33		
16	"	"	7.32		
17	"	"	6.48		
18	"	"	5.78		
19	"	"	5.19		
20	"	"	4.68		
			Value of w.		
1	12	8	129958.4	235.2	234.88
2	"	"	32489.6	"	233.92
3	"	"	14439.82	"	232.36
4	"	"	8122.4	"	230.20
5	"	"	5198.33	"	227.48
6	"	"	3609.95	"	224.24
7	"	"	2652.21	"	220.53
8	"	"	2030.6	"	216.40
9	"	"	1604.42	"	211.90
10	"	"	1299.58	"	207.09
11	"	"	1074.03	"	202.01
12	"	"	902.48	"	196.74
13	"	"	768.98	"	191.31
14	"	"	663.05	"	185.77
15	"	"	577.59	"	180.17
16	"	"	507.65	"	174.54
17	"	"	449.68	"	168.93
18	"	"	401.1	"	163.35
19	"	"	359.99	"	157.85
20	"	"	324.89	"	152.43
21	"	"	294.69	"	147.12
22	"	"	268.5	"	141.94
23	"	"	245.66	"	136.89
24	"	"	225.62	"	131.99
25	"	"	207.93	"	127.24
8	14	8	4188.11	388.08	362.86
10	"	"	2680.39	"	350.06
12	"	"	1861.38	"	335.60

The following table, which gives the results of some forty-one experiments that I have recently made on small cubes and pillars of timber, and indicates the strength of American white pine (*pinus strobus*) pillars, (the house carpenter's wood,) and one experiment for comparison with a spruce pillar. The pillars were very accurately squared and fitted, both ends being flat and firmly fixed, and the experiments were made in a frame constructed of oak timber, and by means of a lever compressing the ends of the pillars which stood perpendicular between two flat and even surfaces of iron, always parallel to each other, and similar to that employed by the late Mr. Eaton Hodgkinson in conducting his experiments.

The pillars were all cut out from the one piece of timber, well seasoned and dried in a room with moderate heat from a stove, and the experiments were conducted in the open air.

I also found, from experiment, the following result: that, of two pillars, one of spruce and the other of pine, both of the same dimensions, namely, three feet high and one inch square, whereas the pine was completely crippled by 1237 lbs., that of the spruce, with a weight of 1514 lbs., remained uninjured and without visible sign of deflection.

The remarks, in the column of remarks in the table, are set down as registered at the time of making the experiments exactly as written down by Mr. John Nader, who assisted me in making them.

TABLE showing the Breaking Weights of Solid Uniform Square Pillars of American White Pine, strength per square inch of section and the calculated breaking weight of the Pillars from the following formulas, both ends being flat and firmly fixed.

$$W = 11133 \frac{D^4}{L^2}$$

$$Y = \frac{W + \frac{3}{4}c}{Wc}$$

Number of experiments.	Length or height of pillar in inches.	Side of the square—inch.	Breaking weight in lbs.	Strength per square inch of section in lbs.	Calculated break'g weight in lbs. from formula $W = 11133 \frac{D^4}{L^2}$	Calculated break'g weight in lbs. from formulas $W = 11133 \frac{D^4}{L^2}$ $Y = \frac{Wc}{W + \frac{3}{4}c}$	REMARKS.
1			1145	4580			Crushed down.
2			1145	4580			“ “
3			914	3656			Yielded laterally.
4			914	3656			“ “
5			1100	4400			Crushed by sliding.
6			1100	4400			“ bending.
7	1		1390	5590		1409	“ top and bottom.
*8	1		1440	5760		1403	“ by sliding.
9	1		1440	5760		1409	“ “
10	2		1390	5560		1367	“ top and bottom.
†11	2		1340	5360		1367	“ by sliding.
12	2		1340	5360		1367	“ “
13	3		1284	5136		1303	“ bending.

Number of experiments.	Length or height of pillar in inches.	Side of the square—inch.	Breaking weight in lbs.	Strength per square inch of section in lbs.	Calculated break'g weight in lbs. from formula $W = 11133 \frac{D^4}{L^2}$	Calculated break'g weight in lbs. from formulas $W = 11133 \frac{D^4}{L^2}$ $Y = \frac{W c}{W + \frac{3}{4} c}$	REMARKS.
14	3	"	1284	5136		1300	Crushed by bending.
15	4	"	1390	5560		1217	" "
16	4	"	1284	5136		1217	" "
17	5	"	1116	4464		1125	" "
18	5	"	949	3796		1125	" "
19	6	"	822	3288		1029	" "
20	6	"	776	3104		1029	" "
21	7	"	868	3472		936	" "
22	8	"	776	3104		847	" "
23	9	"	706	2824		764	" "
24	9	"	799	3196		764	" "
25	10	"	753	3012		689	" "
26	11	"	729	2916		622	" "
27	12	"	580	2320		561	" "
28	12	"	568	2272		561	" "
29	13	"	453	1812		503	" "
30	14	"	453	1812		460	" "
31	15	"	453	1812		418	" "
32	16	"	424	1696		383	" "
33	36	$\frac{3}{4}$	453	604	391		*
34	36	1	1237	1237	1237		†
35	24	1	2368	2368		2247	†
36	18	$\frac{1}{2}$	218	872	308		Broke very suddenly.
37	18	$\frac{1}{2}$	1635	2180	1565		" slowly.
38	18	"	1380	1840	1565		" suddenly.
39	18	"	1422	1896	1565		" very slowly.
40	18	"	1700	2266	1565		" suddenly.
41	24	$\frac{1}{2}$	120				This pillar, when set up, was inclined from the perpendicular one-quarter of its height.

NOTES.

				Deflect'n inch.	Deflecting weight in lbs.	
*33	36	$\frac{3}{4}$	453	$\frac{1}{8}$	168.5	This pillar deflected $1\frac{7}{8}$ inch with 453 lbs., and would have broken had not the bottom of the scale platform rested on ground.
				$\frac{3}{8}$	314.5	
				$1\frac{1}{8}$	360.5	
				$1\frac{3}{4}$	406.8	
				$1\frac{7}{8}$	453	
				$1\frac{1}{2}$	453	
†34	36	$\frac{3}{4}$	1237	$\frac{1}{8}$	591	This pillar broke slowly and yielded diagonally.
				$1\frac{1}{8}$	960	
				$1\frac{1}{4}$	1237	
				$1\frac{3}{4}$	1237	
†35	24	1	2368			This pillar, with this weight, broke suddenly.

Mr. Rennie found that to crush a cube of one inch on the side, the weight in pounds required were as under :

English oak,	.	.	.	.	.	.	3360 lbs.
White deal,	.	.	.	.	.	.	1928 "
American pine,	.	.	.	.	.	.	1606 "
Elm,	.	.	.	.	.	.	1284 "

According to M. Rondelet, a piece of timber diminishes in strength as it begins to bend, so that the mean strength of the wood of the oak, which is 44 lbs., French, for every line superficial in the case of a cube, is reduced to 2 lbs. for a piece of the same wood when its height is 72 times its base. From a great number of experiments he compiled the following progression:

In a cube, the height of which is	1,	the strength is	1.
In a piece, the height of which is	12,	"	.833
"	24,	"	.5
"	36,	"	.33
"	48,	"	.166
"	60,	"	.083
"	72,	"	.041

Thus, in a cube of oak of 1 inch superficial of base, submitted to the action of a force pressing vertically, the mean force is expressed by $144 \times 44 = 6366$. } While the mean of experiments gave { 6346

In a bar of the same wood of the same base, and 12 inches high, the strength by the progression would be } " { 5310

$144 \times 44 \times .333 = 5278$. } " { 2911

In a bar 24 inches high, the strength by the formula } " { 2163

$144 \times 44 \times .5 = 3168$. } " { 2163

In a bar 36 inches, the strength by the formula } " { 2163

$144 \times 44 \times .333 = 2110$. } " { 2163

In a bar 48 = $144 \times 44 \times .134 = 849$.

In a bar 60 = $144 \times 44 \times .083 = 526$.

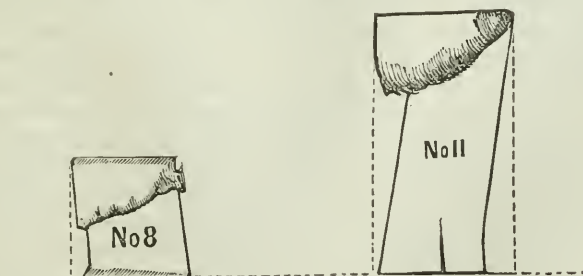
In a bar 72 = $144 \times 44 \times .042 = 266$.

In fir bars the following results were obtained :

	By Calculation.	By Experiment.
In a cube of 1 inch, $144 \times 52 \times 1$.	= 7488	7490
In a bar of 12 inches, $144 \times 52 \times .833$	= 6238	6355
" 24 " $144 \times 52 \times .5$	= 3744	3429
" 36 " $144 \times 52 \times .33$	= 2471	2575

These results, M. Rondelet observes, accord with the experiments of MM. Perrounet, Lamblardie and Girard.

NOTE.—* † Diagram of the experiments Nos. 8 and 11, page 319.—Full size.



The original specimens experimented upon are in the possession of the Franklin Institute, together with ten other specimens of the experiments.

In an experiment described by the latter, a piece of wood 2 metres 273 millimetres long, and 155 by 104 millimetres in section, broke under a weight of 33,120 kilogrammes.

Reducing these to English measures, the length is 7.35 feet, the section of base 6.05 by 4.06 inches. The area of section = 24.563 inches, and as the weight is 72,864 lbs., the weight on the square inch is 2966 lbs.

The height of the piece is about twenty-two times the size of the base, and the progression would give a reduction of half the strength. If, therefore, 2966 is doubled, 5932 lbs. are obtained as the absolute resistance per square inch, a result which agrees very closely with the experiments of M. Rondolet.

(To be Continued.)

The Bulletin of the Belgian Academy of Sciences reports a curious experiment of M. de Wilde, which will have an interest for our theoretical chemists. A piece of spongy platinum is introduced into hydrogen gas over mercury, and when the absorption has ceased, as is indicated by the level of the mercury becoming constant, acetylene is introduced, a very rapid absorption takes place, and new hydrocarbons are formed which have not yet been obtained in other ways.

Cosmos.

Steam Pressure Regulator of M. Eug. Rolland.

The apparatus of M. Rolland works automatically, and regulates the pressure so perfectly as not to allow it to vary more than 0.15 of an atmosphere from the mean pressure desired. It consists of a bent iron tube, with two vertical branches containing mercury,—one branch entering the steam-box through its bottom, while the other opens into the air. In the steam-box the tube terminates in a chamber of large diameter, in which is a cast iron float, made hollow so as to be as light as possible, the hollow being filled with a mixture of bitumen and sand. The steam is introduced into the box by a pipe passing through the upper cover of the box, and vertically above the axis of the mercury chamber. This steam-tube is closed at bottom, and opens into the chamber by means of a number of slots cut through its wall. A sleeve slides easily over the part of the tube in which the slots are cut, and is carried by a vertical stem connected with the float. The length of this stem is so regulated that when the pressure is below the normal the sleeve is above the slots, and the steam openings are, of course, entirely free. As the pressure increases the float descends, carrying the sleeve down over the tubes, and gradually excludes the steam from the box. In order to make the apparatus as sensitive as possible, the movement of the float should be slow so long as the pressure has not attained the normal, and should become very rapid so soon as this is slightly exceeded. This result is obtained by making the float of nearly the

same diameter as the chamber, and arranging a considerable enlargement at that part of the outside tube to which the surface of the mercury corresponds at the normal pressure.

This regulator of M. Rolland has now been in use for several years in the principal tobacco manufactories of Paris, Dieppe, &c., and has always kept the pressure within the limits above indicated. It might, however, if necessary, be made still more precise by connecting the float with a compensating counterpoised lever, such as M. R. has introduced into his thermo-regulator.

Academy of Sciences of Paris.

For the Journal of the Franklin Institute.

A Problem in the Conversion of Mechanical Power into Heat.

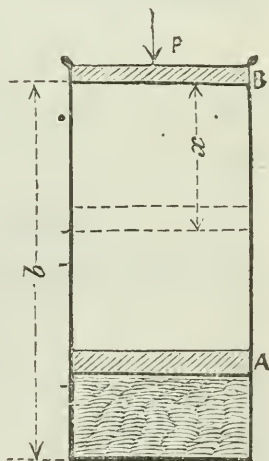
By JOHN D. VAN BUREN, U. S. Naval Engineers.

PROBLEM.—*To find how much the temperature of a given weight of air will be increased by a given gradual compression, and also the mechanical effect expended in producing this compression, supposing no loss from conduction or radiation, upon the hypothesis that heat and mechanical effect are convertible in the ratio of Joule's equivalent.*

Let the figure represent a cylinder, with a piston moving in it without friction or weight, and confining beneath it exactly one pound of air, by means of the compressing force P . Let the piston have an area of exactly one square foot. The problem then is: to determine the increase of temperature of the air due to forcing the piston from B to a given point A , and the mechanical effect expended.

NOTATION.

- p = initial pressure in pounds per square foot exerted by the air against the piston.
- p_x = pressure in pounds per square foot exerted by the air when the piston has been driven through the path x .
- t = initial temperature of air in degrees Fahrenheit above 32° .
- t_x = temperature of air in degrees Fahrenheit above 32° , corresponding with x , p_x and t_x .
- w = weight of one cubic foot of air at temperature t and pressure p .
- ρ = co-efficient of expansion for air for 1° Fahrenheit.
- s = specific heat of air compared with that of water as unity.
- 772 = Joule's equivalent = mechanical effect in foot-pounds equivalent to the heat required to raise one pound of water 1° Fahrenheit.
- x = distance through which the piston has been forced when the temperature and pressure are respectively t_x and p_x .



Now, since the work of resistance is equal to the work of the applied compressing force, we may confine our attention to the former. We may also overlook the influence of the inertia of the air, since the compression is to be *gradual* and with *uniform* velocity. Then, if the piston be forced through the *differential* path dx , from any position x , the work expended upon the piston, and converted into heat in the air, due to this motion, is in foot-pounds,

$$p_x dx, \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

and the temperature added to the air by this must therefore be—

$$dt_x = \frac{p_x dx}{772 s}, \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

But we have, from Gay Lussac's law,

$$\frac{v}{v_x} = \frac{1 + \rho t}{1 + \rho t_x} \cdot \frac{p_x}{p}, \quad . \quad . \quad . \quad . \quad . \quad (3.)$$

Where v = initial volume of air, and v_x = volume of air corresponding with p_x . Then, if b = whole length of cylinder, we shall have—

$$\frac{v}{v_x} = \frac{b}{b-x} = \frac{1 + \rho t}{1 + \rho t_x} \cdot \frac{p_x}{p}, \quad . \quad . \quad . \quad . \quad . \quad (4.)$$

$$\therefore p_x = \frac{p b}{1 + \rho t} \cdot \frac{1 + \rho t_x}{b-x}, \quad . \quad . \quad . \quad . \quad . \quad (5.)$$

Hence, from (2),

$$dt_x = \frac{1}{772 s} \cdot \frac{p b}{1 + \rho t} \cdot \frac{1 + \rho t_x}{b-x} \cdot dx, \quad . \quad . \quad . \quad . \quad . \quad (6.)$$

$$\therefore \frac{dt_x}{1 + \rho t_x} = \frac{p b}{772 s (1 + \rho t)} \cdot \frac{dx}{b-x}, \quad . \quad . \quad . \quad . \quad . \quad (7.)$$

or,

$$\frac{dt_x}{1 + \rho t_x} - \frac{p b}{772 s (1 + \rho t)} \cdot \frac{dx}{b-x} = 0, \quad . \quad . \quad . \quad . \quad . \quad (8.)$$

$$\text{In (8) place the constant } \frac{p b}{772 s (1 + \rho t)} = a, \quad . \quad . \quad . \quad . \quad . \quad (a;)$$

$$\therefore \frac{dt_x}{1 + \rho t_x} - a \cdot \frac{dx}{b-x} = 0, \quad . \quad . \quad . \quad . \quad . \quad (9.)$$

and, integrating by the rules of integral calculus,

$$\frac{1}{\rho} \log_e (1 + \rho t_x) + a \log_e (b-x) + c = 0, \quad . \quad . \quad . \quad . \quad . \quad (10.)$$

where $\log_e$ = Neperian logarithm.

But when $x=0$, $t_x=t$;

$$\therefore c = -\frac{1}{\rho} \log_e (1 + \rho t) - a \log_e b, \quad . \quad . \quad . \quad . \quad . \quad (11.)$$

$$\therefore \frac{1}{\rho} \log_e \frac{1 + \rho t_x}{1 + \rho t} + a \log_e \frac{b-x}{b} = 0, \quad . \quad . \quad . \quad . \quad . \quad (12.)$$

or,

$$\log_e \left[\frac{1 + \rho t_x}{1 + \rho t} \cdot \left(\frac{b - x}{b} \right)^{a\rho} \right] = 0, \quad (13.)$$

Hence,

$$\frac{1 + \rho t_x}{1 + \rho t} \cdot \left(\frac{b - x}{b} \right)^{a\rho} = 1, \quad (14.)$$

and, solving for t_x ,

$$t_x = \left[(1 + \rho t) \left(\frac{b}{b - x} \right)^{a\rho} - 1 \right] \div \rho, \quad (16.)$$

Now, introducing the value of a ,

$$t_x = \left[(1 + \rho t) \left(\frac{b}{b - x} \right)^{\frac{p b \rho}{772 s (1 + \rho t)}} - 1 \right] \div \rho, \quad (17.)$$

But $b = \frac{1}{w}$;

$$\therefore t_x = \left[(1 + \rho t) \left(\frac{b}{b - x} \right)^{\frac{p \rho}{772 s w (1 + \rho t)}} - 1 \right] \div \rho, \quad (18.)$$

If w_0 = weight of one cubic foot of air at temperature 32° Fahrenheit, and pressure $p_0 = 14.76 \times 144$ lbs. per square foot, then

$$w = \frac{p}{p_0} \cdot \frac{w_0}{1 + \rho t}, \quad (b.)$$

Introducing (b) in (18) we get—

$$t_x = \left[(1 + \rho t) \left(\frac{b}{b - x} \right)^{\frac{p_0 \rho}{772 s w_0}} - 1 \right] \div \rho, \quad (19.)$$

It will be observed, in (19), that t_x is independent of the pressure, since $\frac{p_0}{w_0}$ is constant. This is correct; for we have taken a constant weight of air, and the path of the work of compression must therefore vary inversely as the initial pressure, the initial temperature remaining the same, no matter what the degree of compression. The effect of increasing the initial temperature above 32° is observed to be to increase the temperature t_x just 100 ρt per cent. This is also correct; since, if we have the same initial pressure, the path of the work of compression is increased precisely 100 ρt per cent. by this increase of initial temperature, no matter what the degree of compression; and, therefore, the temperature t_x should also be increased by this amount, *since the increase of temperature measures the work done.* If $x = 0$, $t_x = t$; if $x = b$, $t_x = \infty$, which are correct results.

By introducing the values of ρ , ρ_0 , w_0 , and s , the formula becomes very simple:

$$\rho = .002039,$$

$$s = .238,$$

$$p_0 = 14.76 \times 144 = 2125.44,$$

$$w_0 = .081241 \text{ lbs.};$$

$$\therefore t_x = \left[(1 + .002039 t) \left(\frac{b}{b - x} \right)^{.290333} - 1 \right] \div .002039$$

$$= \left[(491 + t) \left(\frac{b}{b-x} \right)^{.290333} - 491 \right] \quad (20,)$$

and, putting $\frac{b}{b-x} = r = \text{degree of compression}$, we finally get—

$$t_x = (491 + t) r^{.290333} - 491, \quad (21.)$$

The mechanical effect expended, or *work* of resistance is, for w pounds of air,

$$W = 772 s (t_x - t) w, \quad (22,)$$

$$= 183.74 (t_x - t) w, \quad (23,)$$

since every degree of temperature added must be produced by the conversion of 183.74 lbs. feet into heat.

HEAT PRODUCED BY IMPACT.

If a force P strikes the piston moving with a velocity of v feet per second, and is brought to rest by the *cushioning* of the air, which is not allowed to rebound after the greatest compression, the work (= one-half the *living force*) of the blow is—

$$W = \frac{P v^2}{2g}, \quad (24,)$$

when $g = 32\frac{1}{6}$ feet, and hence the increased temperature due to this blow, and appearing in the air, is—

$$t_x - t = \frac{P v^2}{2 \times 772 s g} = \frac{P v^2}{367.472 g} = .0000846 P v^2, \quad (25,)$$

in degrees Fahrenheit.

But, if the weight of air be w pounds, then—

$$t_x - t = .0000846 \frac{P v^2}{w}, \quad (26,)$$

when $t_x - t$ is *temperature* added, not units of heat.

A very striking instance of the conversion of mechanical power into heat is the heating to *redness in broad daylight* of an iron target when struck by a heavy shot from a cannon. The heat is often so intense as to weld the shot firmly in the target.

EXAMPLES UNDER EQUATIONS (21), (23,) AND (26).

EXAMPLE 1.—Required the temperature of 10 lbs. of air after compressing it, from a temperature of 32° Fahrenheit, into one-fifth of its original volume, and the mechanical effect expended. In (21) make $t = 0$, and $r = 5$;

$$\begin{aligned} \therefore t_x &= 491 \times 5^{.290333} - 491 \\ &= 292.4, \end{aligned} \quad (1.)$$

$$\begin{aligned} W &= 183.74 (t_x - t) w = 183.74 \times 292.4 \times 10 \\ &= 537255.76 \text{ lbs. feet.} \end{aligned} \quad (2.)$$

From this and other calculations we get—

Initial Temperature 32° , $t = 0$. Initial Temperature 132° , $t = 100^\circ$.

Compression to one-fifth,	$t_x = 292^{\circ}\cdot 4$	$t_x = 452^{\circ}\cdot 0$
“ one-tenth,	$t_x = 467^{\circ}\cdot 1$	$t_x = 662^{\circ}\cdot 2$
“ one-twentieth,	$t_x = 680^{\circ}\cdot 7$	$t_x = 919^{\circ}\cdot 3$

The increase in temperature, for the six cases in order, is—

$t_x - t = 292^{\circ}\cdot 4$	$t_x - t = 352^{\circ}\cdot 0$
“ $= 467^{\circ}\cdot 1$	“ $= 562^{\circ}\cdot 2$
“ $= 680^{\circ}\cdot 7$	“ $= 819^{\circ}\cdot 3$

The temperatures above zero, Fahrenheit, are—

$t_x + 32 = 324^{\circ}\cdot 4$	$t_x + 32 = 484^{\circ}\cdot 0$
“ $= 499^{\circ}\cdot 1$	“ $= 694^{\circ}\cdot 2$
“ $= 712^{\circ}\cdot 7$	“ $= 951^{\circ}\cdot 3$

As a proof of the arithmetical work, to tenths of a degree, we have

$$\frac{352 - 292\cdot 4}{292\cdot 4} = \frac{562\cdot 2 - 467\cdot 1}{467\cdot 1} = \frac{819\cdot 3 - 680\cdot 7}{680\cdot 7} = \cdot 204.$$

EXAMPLE 2.—A cylinder containing ten cubic inches of air, confined by a plunger-piston receives a blow upon its piston from a weight $P = 10$ lbs., moving with a velocity of 30 feet per second. Required the temperature given to the air, supposing the initial temperature 32° Fahrenheit.

$$t_x - t = \frac{\cdot 0000846 \times 10 \times 900}{\cdot 081241 \times \frac{10}{1728}} = 1619^{\circ}\cdot 5$$

$$t_x + 32 = 1651^{\circ}\cdot 5 \text{ Fahrenheit.}$$

This affords an explanation of the well known experiment of lighting tinder by sudden compression of air. The principles involved in equation (21) are involved in the problem of finding the amount of condensation taking place in the cylinder of a steam engine, using steam *expansively*.

The writer hopes to give a solution of this last problem at some future time, and it is with this design in view that this paper is offered for publication.

Bureau of Steam Engineering, March 20, 1866.

Water Freezing at a Depth of Twenty-five Feet.

We copy from the *Detroit Free Press* the following article, on account of the singularity of the difficulty which it sets forth, and because it may, in many cases, be of importance to engineers to be aware that such effects may occur. The explanation suggested by Prof. Douglass is undoubtedly correct, the phenomenon of ground-ice having been long known and carefully observed, and the remedy which he proposes would doubtless be effectual. It may, perhaps, be added, that, when a platform floating on the water would be in the way of navigation, a wooden shield secured a few feet above the mouth of the pipe would secure the same result.

The Water Commissioners have encountered a difficulty in obtaining water from the river in the winter, which may be considered a singular phenomenon. A brief description of the inlet pipe and nature of the difficulty may be interesting. The inlet pipe to the pump

well is made of boiler iron; it is 30 inches diameter; its extreme length is about 220 feet, and it extends into the river 150 feet from the wharf, into water 34 feet deep at the extreme end. On the river end of the pipe there is a bell-shaped mouth, elbow turned upwards, the end of which is 36 inches diameter, over and surrounding which there is a strainer, also made of boiler iron, 9 feet diameter and 10 feet high; above the end of the pipe the boiler plate in the strainer is punched with half-inch holes—144 to each square foot. Surrounding the mouth of the pipe, and inside the shell of the strainer, there is a diaphragm plate, also punched with half-inch holes. Below the diaphragm plate, the shell of the strainer is punched with four-inch holes, to allow the sand to pass through and not bank up on the outside of the strainer. The pipe is covered with a large quantity of building stone. The water is drawn from the well by a steam pumping engine, and when the engine is pumping, the water is required to pass through the holes in the strainer at the rate of 120 barrels per minute to furnish an adequate supply. The water is 25 feet deep over the top of the strainer; the current of the river is about three miles per hour.

Under certain circumstances, during extreme cold weather, it is with difficulty a supply of water can be obtained, in consequence of the accumulation of ice on the strainer, frequently requiring the speed of the engine to be reduced, and at times to stop it for several hours together, for no water passed through the pipe into the well, and the water in the well would be exhausted, notwithstanding the bottom of the well is 12 feet below the surface of the river. Size of well about 40 feet long, 18 feet wide, and 12 feet deep.

The circumstances under which the difficulty occurs, are when the weather is cold, and ice is forming in the lake above, and on the shores of the river, and the river is open free from ice over the strainer. But when the river is covered with ice over the strainer, the difficulty does not occur at any degree of cold. The greatest difficulty occurs when the thermometer ranges from 7° or 8° to 18° or 20° above zero, greater than when it is below zero, and when the mercury rises above 20° , however sudden, the difficulty immediately ceases. The greatest difficulty, it has been observed, occurs at night, and when the sun is obscured by clouds, but when the sun is unclouded no difficulty is ever experienced. This difficulty has been encountered in supplying the city with water for many years.

Dr. Pitcher addressed a letter to Professor Douglass, of the State University, enclosing one from Mr. R. E. Roberts, Secretary of the Water Commissioners, detailing the facts given above, and asking an explanation of this phenomenon. The following is the reply of Professor Douglass:

UNIVERSITY OF MICHIGAN,

January 29, 1866.

ZINA PITCHER, M. D., Detroit.

Dear Sir: Your letter, covering a communication from R. E. Roberts, Esq., in relation to the obstruction of the supply pipe at the water works in your city, was duly received, and I have given the subject careful consideration. With the facts

which the letter affords, I am unable to give an explanation of the singular phenomena entirely satisfactory to myself. Mr. Roberts states that the ice does not form on the strainer when the sun shines, but does not give the effect of a cloudless night. Probably no observations have been made. I think, however, on careful investigation, that this will be found to be the most favorable condition for the deposition of ice. Should this prove true, I should explain the phenomena upon the principle of Wells' well-known and acknowledged theory of the formation of dew, viz: by radiation.

The extremity of the pipe is a good radiator of caloric as well as a good absorber. When the water reaches about the temperature of 32° , the pipe, parting with its caloric by radiation into space, is so far reduced in temperature as to cause the water to congeal upon its surface. The clear water, being to a great extent translucent, would not interrupt the passage of the caloric. Nor would the great depth affect it, for it is well known that caloric that has been transmitted through one layer of a translucent medium will be transmitted through any number of layers. The rays of the sun would also convey heat through the water to the pipe, (a good absorber of caloric,) and thus dissipate the ice. As soon as the ice forms upon the river, all radiation and transmission of caloric would be stopped by the intertranscendency of the ice. Upon this theory, we should have ice most freely deposited on the strainer in clear and cloudless nights before ice has covered the river. It would also be dissipated in a cloudless day. The last seems to be true, if not the first.

Assuming this as the true theory, I would suggest the following remedy of the evil: Procure three or four large scows or a timber-raft, and have them anchored directly over the pipe. They will intercept the heat radiated from the pipe, and send it back again to the source from whence it came. If the evil is a serious one, the experiment is worthy of a trial. I think the scows will prevent the ice forming on the strainer.

Very respectfully,

SILAS H. DOUGLASS.

Apparatus for the Detection of Explosive Gases in Mines.

From the London Chemical News, No. 315.

The lamentable accidents which from time to time occur in coal mines, causing such great destruction of life and property, have engrossed the attention of scientific men ever since the results of the study of natural phenomena have been practically applied to everyday life. Numerous methods of illuminating the mines in such a manner as to prevent the ignition of the combustible gases, but at the same time producing sufficient light to enable the men to work in comfort, have been suggested and employed with varying success.

Next to preventing the accumulation and explosion of inflammable gas in the mines, the possibility of ascertaining with safety its presence is a matter of some importance, as it would enable the overseer to guard against incautious working in a dangerous part of the pit, and to prevent too great an accumulation of the explosive mixture by directing special attention to the ventilation. The process formerly employed by the miners to detect the presence of the inflammable gas, and which cannot be recommended as a safe one, was to bring a lighted candle into the suspected atmosphere, when the peculiar shape assumed by the candle flame gave the required information. This process cannot be too strongly reprehended, and it is probably the cause of many of the fearful accidents which have already taken place.

Another method, which is much more safe, but which is not unattended with danger, is to observe the flame of a Davy lamp. A careful viewer invariably reduces the flame of the Davy lamp to the smallest size that will emit white light before testing for gas, or, as he calls it, "trying a fiery place." When the atmosphere consists of a violently explosive mixture, one hears a peculiar and sharp click, and observes a rapid combustion of the gas within the wire gauze of the safety lamp; when the quantity of carburetted hydrogen is less, the flame of the lamp elongates; and when the quantity is very small, a peculiar lambent cap of a bluish color is observed covering the flame of the lamp. These indications can only be learned by experience in the mines, and, when not properly attended to, might give rise to disastrous results. Should the atmosphere be explosive, the viewer or fireman lowers his lamp very slowly and cautiously until it has passed out of the explosive mixture, which usually occupies the upper part of the gallery of a mine, and travels in that position, notwithstanding the law of diffusion. There are many well authenticated cases of explosions through the gauze of the Davy lamp in a quiet atmosphere, and where the lamps, after the explosions, have been ascertained to be in good order.

A very ingenious instrument has recently been devised for the detection and quantitative estimation of the explosive gases by Mr. G. F. Ansell, of the Royal Mint. The instrument, which may be constructed in several different forms, is based upon the well known law in accordance with which gases gradually mix with one another through porous septa, and even through some materials which do not appear to possess any interstices through which the gases might pass.

If a tube blown out into a cup at one end, (Fig. 1,) and bent in the form of the letter U, be filled with mercury, so that the mercury stands in the cup, and the cup closed by a piece of porous tile cemented on by a resinous varnish, a very serviceable indicator is obtained. On bringing this instrument into an atmosphere containing a gas differing from that contained within the cup, perceptible diffusion takes place through the unglazed earthenware. If the cup be filled with air and the apparatus introduced into an atmosphere of hydrogen, the hydrogen will pass into the cup more rapidly than the air will pass out, according to the well known law that "gases diffuse into one another in the inverse proportion of the square roots of their specific gravities." The specific gravity of hydrogen being 1, that of air is 14.4. As the square root of 14.4 is 3.8, for every one part of air which diffuses out of the cup 3.8 parts of hydrogen will pass in through the porous tile. Thus the pressure on the mercury within the closed limb will exceed that on the mercury in the open limb, and a corresponding elevation of the mercury in the open limb will result. When the maximum effect has been produced, the pressure within the cup will gradually force the



gas through the porous diaphragm until the mercury stands level in both limbs. At this point the gases within and without the apparatus possess the same composition, but any change of proportions in the external atmosphere is immediately indicated by the level of the mercury. If the instrument be removed into the air, the hydrogen within will immediately diffuse outward, and a rise of the mercury in the closed limb will result.

If the apparatus containing air be placed in an atmosphere of a gas of greater density than the air—as, for instance, carbonic acid—diffusion will take place, but the converse phenomena will be observed. The specific gravities of air and carbonic acid being in the proportions of 14.4 to 22, the diffusion will take place in the ratio of 4.7 to 3.8, *i. e.* for every 4.7 volumes of air which pass outwards, 3.8 of carbonic acid will pass inwards, so that the pressure on the mercury in the open limb will exceed that in the closed limb, and the mercury in the latter will rise; the alteration of level obviously being less than in the previous case, in which hydrogen was without a diaphragm. Of course, the theoretical elevation and depression of the mercury can in no case be observed, for, during the whole time that diffusion is going on, effusion takes place in consequence of the increased or diminished pressure of the apparatus. Mr. Ansell has constructed several pieces of apparatus on this principle. One (Fig. 1) consists simply of the U-tube with a scale graduated so as to indicate the per centage of mine gas present. In another form of the apparatus (Fig. 2) *a* is a piece of biscuitware cemented to a glass vessel (*b*), which at its lower end communicates with a U-tube containing mercury, on which, as it rises in the open limb, there floats a small weight, to which is fastened a cord passing over a pulley and counter-balanced on the opposite side, the rise and fall of the mercury causing the pulley to revolve and to indicate the alteration of pressure by the movement of a pointer on a dial (*c*). This is for use *only* on occasion of a sudden irruption of fire-damp.

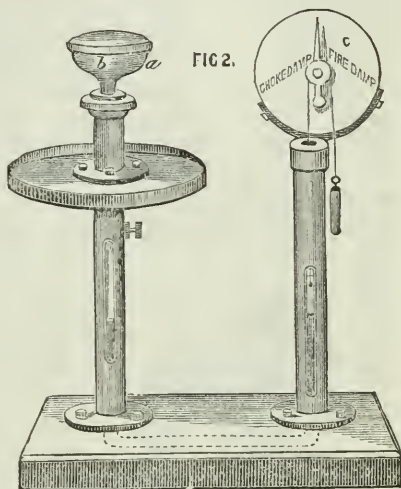


Fig. 3 is a section of a porous battery cell which is used instead of the glass vessel (*b*) in Fig 2, but it does not give better results than those attained by the tile (*a*).

Another apparatus (Fig. 4) on the same principle has been con-

structed by enclosing a U-tube with a bulb containing mercury in an inverted porous battery cell. The edge of the cell is firmly cemented on to a piece of wood; a small metal weight floats on the surface of the mercury in the tube, and is attached to a piece of string, which passes over a pulley, and, by the alteration of the mercury level in the tube, moves an index, as in the previous form of the apparatus. On bringing the porous cell into a gas containing carburetted hydrogen, some of the gas diffuses into the cell, causing a rise of the mercury in the glass tube and a corresponding movement of the index.

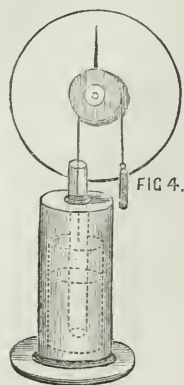


FIG. 4.

All these modifications of the apparatus must be watched in order to obtain any information from them; but Mr. Ansell has constructed an alarum, which rings a bell if any quantity of gas SLOWLY ACCUMULATES round the indicator. The

instrument, (Fig. 5,) consists of one of the thin india rubber balloons (a) so well known at the present time. One of these is placed on a piece

of brass, which can be raised and lowered by a screw. The upper end of the balloon presses against a lever (b), which, when raised, liberates a train of clock-work at (c), and rings a bell (e). To increase the movement of the lever a band of linen is bound around the equator of the balloon in order to prevent lateral expansion and to concentrate all increase of volume in a polar direction. If this apparatus be placed in the gallery of a mine, the presence of or an increase in the quantity of mine gas will cause the expansion of the balloon, and consequent ringing of the alarum. The balloon remains in its expanded state until the composition of the atmosphere is altered.

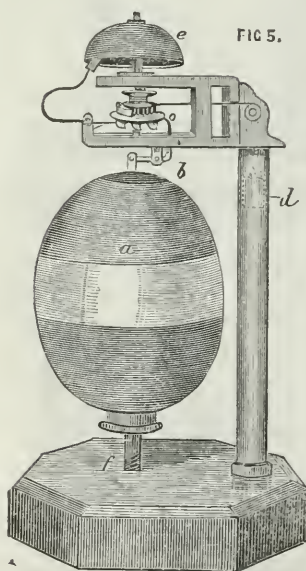


FIG. 5.

Mr. Ansell has devised an instrument which, for elegance and utility, far surpasses all the others, as it admits of the determination of the quantity of mine gas present in a mixture. The apparatus consists of a small aneroid barometer, the case of which is made perfectly air-tight, but the interior of which may be placed in communication with the external air by opening a small screw fastened on the handle. The brass back of the barometer is replaced by a thin plate of porous earthenware, and may be covered with a brass cap or back placed on a hinge like that of a watch. Under ordinary circumstances the screw remains open, but when it is required to test the

gas in a mine, the screw is closed and the cap removed from the porous plate. Immediately diffusion takes place, and, the pressure increasing, causes a corresponding movement of the hand of the barometer. In about forty-five seconds the maximum effect is produced, when the position of the hand indicates, by means of a vernier, the per centage of mine gas present. If the apparatus be left for a sufficient time, the internal pressure forces the excess of gas through the porous plate, and the needle returns to the zero point. On subsequently allowing diffusion to take place into pure air, the index retrogrades to the same extent (if the mixture does not contain more than 10 per cent. of mine gas or "fire-damp") to which it had previously advanced. This apparatus, which is not larger than an old-fashioned watch, will undoubtedly prove of great service to the mine overseer, as it can at any time be carried into the gallery of a mine. The per centage of gas is determined in less than a minute.

As is to be expected, the motion of the train of trucks running into or out from the pit, causes a variation of the pressure; therefore it is necessary to avoid such intervals in making observations by the instrument last described. It is well to mention that temperature need not be taken into account, for it is found that the temperature of the same part of a mine does not vary from year's end to year's end. The instruments denoted by Figs. 2, 4, and 5 are connected with telegraph arrangement, and these, as well as the aneroid barometer, have given full satisfaction to practical miners in several mines where they have been tried.

On some of the most Important Chemical Discoveries made within the last Two Years. By Dr. F. CRACE CALVERT, F. R. S., F. C. S.

II.

(Continued from page 262.)

From the London Journal of the Society of Arts, No. 673.

On the Discoveries in Chemistry applied to Arts and Manufactures.

—One of the most curious and important applications which have lately been made of chemistry to manufactures is that of coal gas as a means of obtaining intense heats. In fact, heats have been secured which far exceed those previously obtained by the combustion of coals and other carbonaceous matters.

To understand how this result has been effected, it is necessary that I should say a few words on the combustion of coal gas. When coal gas is ignited, the oxygen of the atmosphere first combines with the hydrogen of the hydrocarbons, either gaseous or sufficiently volatile to assume a gaseous form, so as to produce water. Whilst a part of the carbon of these hydrocarbons combines with the oxygen to produce carbonic acid, the other portions of carbon float in the mass of ignited gaseous matters, and reach a sufficient temperature to radiate light in all directions. It follows, therefore, that the richer the coal gas is in hydrocarbons, into the composition of which enters a large proportion of carbon, the more brilliant will be the flame.

This is beautifully illustrated by an invention which I have the pleasure of showing you through the kindness of Rev. Mr. Bowditch, of Huddersfield, who has lent me one of the apparatuses which he has lately invented to increase the illuminating power of inferior coal gas, and which has been applied with success in the city of London, by its learned officer of health, Dr. Letheby. It consists in the introduction of carburetted hydrogens, rich in carbon, into the flame of ordinary coal gas, thus enhancing, in a marked degree, its illuminating power. This apparatus consists of a gas-tight metallic vessel, which holds the hydrocarbons, and which has an inlet connected with a gas supply and an outlet connected with the burner. The gas in its course passes over the surface of the hydrocarbons. Being above the flame, the vessel and its contents become heated, and part of the latter is converted into vapor, which the passing gas carries with it to the burners to enrich the flame.

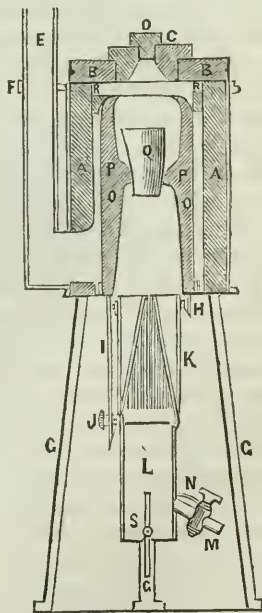
The following are the advantages which Mr. Bowditch's apparatus presents: Common coal gas, Ashburton flat flame, fish-tail, and bat-wing does not yield a light of 1·5 standard sperm candles per foot, though it yields the light of 2·4 candles per foot when burnt in a 15-hole Argand with a 7-inch chimney. By adding 31·5 grains of naphthalin vapor to each foot of this gas the light-giving value is raised to between seven and eight candles per foot, according to the constitution of the gas with which the vapor is burnt. Oils do not yield quite so high a result as naphthalin, but they afford from 4·5 to 5 times the light given by gas alone. To show the economy of gas, I may cite the following results, given to me by Mr. Bowditch: A gallon of oil, sold retail for 2s., is capable of producing, with 1000 feet of London gas, more light than is given by 4000 feet of gas, or 4s. 6d. gas and 2s. oil against 18s. gas alone. The hydrocarbon vessel requires charging about once in 14 to 16 days.

But let us now return to the production of intense heat by the combustion of coal gas. This is effected by burning gas with an excess of air, generally speaking, under pressure, so as to bring into contact in a given space of time a large quantity of gases, especially an excess of oxygen, with a view of rendering perfect combustion of coal gas. The first instance, to my knowledge, of the perfect combustion of coal gas as a commercial application, was its use in machines for singeing cotton and woollen fabrics, or for the purpose of removing from their surface all loose and useless fibres. One of the most perfect machines which I have yet examined for accomplishing this purpose has been lately introduced to the notice of manufacturers by Joshua Schofield & Sons, of Manchester. The great merit of their machine consists in the fact that by it they can vary either the intensity of the flame or its length, according to the pressure at which the gases in combustion are made to issue from the machine. In fact, they can adapt with such nicety the action of the machine to the nature of the fabrics they have to singe, that it can be applied to the finest fabric, such as cambrics, and to some of the heaviest materials in cotton, such as fustian.

The most remarkable example of the intense heat which can be

obtained by the combustion of gases was brought into notice a few years since by that distinguished chemist M. H. St. Clair-Deville, (the discoverer of aluminium,) by which he succeeded not only in melting several metals which, until his experiments, had resisted all other modes of effecting their fusion, but in melting in his laboratory as much as 25 lbs. of platinum, one of the most refractory metals known, and running it into one solid ingot. In 1862, the well known metallurgists, Messrs. Johnson & Matthey, invited to their works a large circle of the most scientific men of Europe, who were attending the Exhibition as jurors, to witness the fusion of 220 lbs. of platinum, and the running of it into one single solid ingot. This wonderful exploit in the production of heat was effected in a furnace similar in principle to that which had been devised by M. St. Clair-Deville, viz: in a furnace, the inner part of which was lined with blocks of quick lime, the only material found by M. Deville to be susceptible of resisting the intense heat which was produced by bringing at the upper part of the furnace a large jet of gas and air intimately mixed, and working under pressure. The flame, in passing from the upper part of the furnace and making its exit at the lower part, produced so great a heat as to melt the above stated quantity of platinum.

The observations of M. Deville soon brought into existence some extremely simple and handy furnaces to effect fusions and assays on a laboratory scale. Some of the best furnaces contrived for that purpose are due to Mr. J. J. Griffin, of Bunhill-row. The principal feature of his furnace is using as a generator for heat a large Bunsen burner, which consists of a hollow tube, at the bottom of which there is an inlet for coal gas, and at a certain height in the tube a number of openings through which the air rushes in to mingle with the gas; both air and gas issue at the top of the tube, and when ignited produced an intense heat. The flame so produced is made to play round a crucible containing the materials to be assayed, and which itself is surrounded by thick earthenware tiles, preventing the heat passing through the furnace from radiating itself in all directions, thus concentrating its action entirely on the little crucible placed in the centre. But the most perfect contrivance of the sort which has yet been brought to the notice of the public is one due to Mr. G. Gore, F.R.S. The following is the description of Mr. Gore's gas furnace: A is a cylinder of fire-clay, about 9 inches high and 6 inches diameter, open at both ends, and with a hole at the back part near the bottom, to lead into the chimney; it



is covered by a movable plate of fire-clay B, with a hole in its centre for the introduction of the crucible or of substances to be melted. This hole is closed by a perforated plug of fire-clay C, for access to the contents of the crucible; and that again is closed by another stopper of fire-clay D. E is a chimney of sheet iron, about 5 or 6 feet high, kept upright by a ring of iron F, attached to the top of the furnace. The fire-clay cylinder is enclosed in a sheet iron casing with a bottom of iron, to which are fixed three iron legs G. An iron tube H, with a prolongation I, supports, by means of the screw J, the burner K, and its tube L, which is open at both ends. Gas is supplied to the burner by means of the tap M, which has a small index N, attached to it for assistance in adjusting the gas. Inside the largest cylinder is another fire-clay cylinder or cupola O, with open ends, and with three projections of fire-clay P, for supporting the crucible Q; it is kept steady by means of three clay wedges R; S is an air-valve for closing the bottom of the tube L. The gas burner is a thin metal cylinder, deeply corrugated at its upper end, with the corrugations diminishing to nothing at its lower end, as shown in the engraving. The action of this furnace is as follows: Gas is admitted to the open tube L by the tap M; it there mixes with air to form a nearly combustible mixture, which ascends through the burner, and burns in the clay cylinder O, being supplied with the remainder of air necessary to combustion through the tube H to the outer surface of the flame by means of the spaces between the corrugations. The flame and products of combustion pass up through the cylinder O, and then downwards outside of it to the chimney, the point of greatest heat being at Q.

Mr. Gore states that one of his smallest furnaces, consuming 33 feet of coal gas per hour, is capable of melting 8 ounces of copper and 6 ounces of cast iron; that the next sized furnace, consuming about twice the quantity of gas, will melt 40 ounces of copper.

But the most important improvement which has been effected of late years in the production of intense heat by the combustion of the gases generated through the distillation of inferior coals, is that of Mr. C. W. Siemens, F.R.S., of Great George Street. The benefits which are conferred on manufacturers and the public by the furnaces devised by Mr. Siemens cannot be overrated. They are not only economical in their use, but as they enable the manufacturer to use an inferior class of fuel to generate the heat required, they must undeniably be of great advantage; and to the public in general they will be a great boon, as they do away with the nuisance attached to all manufacturing districts, in the dark black smoke escaping from chimneys, polluting the atmosphere, and rendering it so disagreeable to those who are compelled by their occupations to live within reach of its influence.

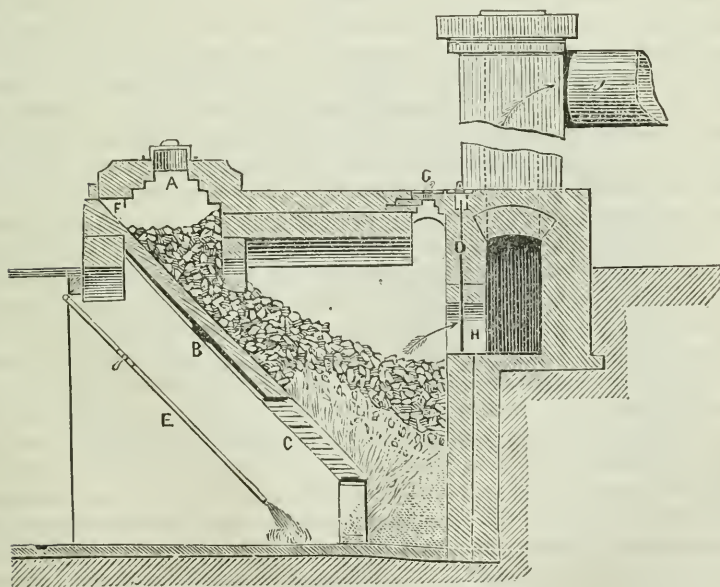
I may state, *en passant*, that the large amount of black smoke which floats in the atmosphere of Manchester, Sheffield, Birmingham, and other towns, is not only injurious by depriving those places of much light so beneficial to life and health, but is also a nuisance from the immense amount of soot and dirt with which it is accompanied. There cannot be a doubt that, owing to the imperfect combustion which the

products undergo in many of the furnaces belonging to manufacturers, and which is shown by the appearance of the smoke itself, the air is rendered more unwholesome than it would be if the products that escape had undergone perfect combustion, because volatile matters escape which are known to have a most destructive action on health and vegetation. The improved state of public squares in London—and of especially those which are on the banks of the Thames—can be witnessed by all who have observed their condition since the consumption of smoke has been made compulsory in London and its suburbs.

Mr. Siemens' furnaces, I am happy to say, are not in a state of mere experiment, but they have received the sanction of a great number of manufacturers, and especially of those who little expected that the necessary heat for their operations could be obtained without interfering with their manufacture, in the carrying out of which they thought the production of smoke could not be prevented. Thus we find M. Siemens' furnaces employed with great success and economy in glass-works, in potteries, and in iron forges, works which used to be a nuisance to their neighbors, by the large volumes of black smoke which they were constantly emitting from their chimneys.

Before describing M. Siemens' furnace, it is necessary that I should state that, in the ordinary furnaces, only about 25 per cent. of the

Fig. 1.



heating power of the fuel is rendered available in carrying out the manufacturing operations. This is due to imperfect combustion, and to the fact that only the heat of combustion exceeding that of the body treated is utilized; the remainder of the heat, in many instances by

far the greater proportion of the whole, being allowed to escape uselessly up the chimney.

I shall now give a description of one of Mr. Siemens' furnaces. The gas producer and furnace are quite distinct, and may be placed at any convenient distance from each other. The gas producer is shown in Fig. 1. The fuel is supplied at intervals of about two hours through the covered openings A, and descends gradually on the inclined plane B, which is set at an inclination to suit the kind of fuel used. The upper portion of the incline B is made solid, being formed of iron plates covered with fire-brick, but the lower portion c is an open grate formed of horizontal flat steps. The opening under the lower step is made larger than the others, to enable clinkers to be withdrawn. The small stoppered holes FF at the front and GG at the top of the producer are provided to allow of putting in an iron bar occasionally to break up the mass of fuel and detach clinkers from the side walls. Each producer is capable of converting daily about two tons of fuel into a combustible gas, which passes off through the opening H into the main gas flue leading to the furnaces.

The action of the gas producer in working is as follows: The fuel descending slowly on the incline plane B becomes heated and parts with its volatile constituents, the hydrocarbon gases, water, ammonia, and a small proportion of carbonic acid, which are the same as would be evolved from it in a gas retort. There now remains from 60 to 70 per cent. of purely carbonaceous matter to be disposed of, which is accomplished by the current of air slowly entering through the grate c, producing regular combustion immediately upon the grate: but the carbonic acid (an incombustible gas) thus produced, having to pass slowly through a layer of incandescent fuel from two to three feet thick, takes up another equivalent of carbon, and is thus transformed into carbonic oxide (an inflammable gas) which passes off with the other combustible gases to the furnaces. For every cubic foot of carbonic oxide thus produced, taking the atmosphere to consist of one-fifth part by volume of oxygen and four-fifths of nitrogen, two cubic feet of incombustible nitrogen pass also through the grate, tending greatly to diminish the richness or heating power of the gas. Not all the carbonaceous portion of the fuel is, however, volatilized on such disadvantageous terms; for water is brought to the foot of the grate by the pipe E, which, absorbing the spare heat from the fire, is converted into steam, and each cubic foot of steam, in traversing the layer of from two to three feet of incandescent fuel, is decomposed into a mixture consisting of one cubic foot of hydrogen, and nearly an equal volume of carbonic oxide, with a variable small proportion of carbonic acid. Thus one cubic foot of steam yields as much inflammable gas as five cubic feet of atmospheric air; but the one operation is dependent upon the other, inasmuch as the passage of air through the fire is attended with the generation of heat, whereas the production of the water gases, as well as the evolution of the hydrocarbons, is carried on at the expense of heat. The generation of steam from the water, being dependent on the amount of heat in the fire, regulates itself

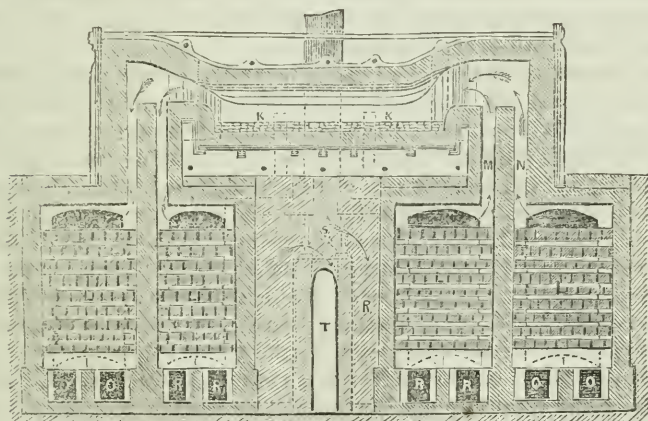
naturally to the requirements; and the total production of combustible gases varies with the admission of air, and since the admission of air into the grate depends in its turn upon the withdrawal of the gases evolved in the producer, the production of the combustible gases is entirely regulated by the demand for them.

The gas made in these producers has been frequently carefully analyzed, and the average constituents of 100 parts has been found as follows:

Carbonic acid, ...	4.1
Oxygen, ...	0.4
Carbonic oxide, ...	23.7
Carburetted hydrogen, ...	2.2
Hydrogen, ...	8.0
Nitrogen, ...	61.5
	99.9

The furnaces are applicable for all purposes where intense heat is required, such as for glass-houses, puddling, heating iron and steel, iron melting for foundry purposes, steel melting, muffles, and copper smelting. In all applications the furnaces are of the same construction in principle, the arrangements only varying with the different operations to be carried on in the heating chamber. The heating furnace has been selected for illustration in Fig. 2.

Fig. 2.



Underneath the heating chamber *K* are placed transversely the four regenerators *L, L, L, L*, which are chambers filled with fire-bricks built up with spaces between them. The regenerators work in pairs, the two under the right-hand end of the furnace communicating with that end of the heating chamber, while the other two communicate with the opposite end.

The gas passes from the main gas flue through the reversing valve *S* into the flues *RR*, at the bottom of one of the regenerators *L*, up through which it passes to the port *M*. Air is also admitted through a revers-

ing valve at the back of S, (not shown in the figure,) thence into the flues o o, up through the second regenerator L to the port N, where it meets with the gas, mingles with it, and produces an intense and uniform flame, which distributes itself all over the heating chamber K.

The products of combustion, together with the excess or waste heat of the furnace, instead of being passed, as in ordinary furnaces, up the stack, and either entirely thrown away or only partially utilized, are carried down into the other pair of regenerators, where they are deprived of their heat, and thence proceed through the reversing valves to the chimney by the flue T.

When one pair of regenerators has become considerably heated by the passage of the hot products of combustion for some time, and the opposite pair correspondingly cooled by the upward passage of the cold gas and air, the valves are reversed, and the currents of gas and air then pass upwards through the regenerators last heated, whereas the products of combustion pass through those opposite. The process of reversing is repeated at fixed intervals, generally every half-hour, so that two of the regenerators are always being cooled by the gas and air taking up the deposited heat and carrying it back to the furnace, and two always being heated by the passage of the hot products of combustion passing down to the chimney, and depositing their heat on their way there.

The flame in the heating chamber is uniform throughout, and perfectly free from all extraneous matter. Its chemical nature is also perfectly under command by means of gas and air regulating valves, (not shown in the engravings,) so that the most delicate operations can be carried on with great uniformity.

The gas and air reach the heating chamber (after passing through the regenerators) at nearly the heat of that chamber itself, and in burning, in addition to the temperature due to their mutual chemical action, is added that they have taken up in passing through the regenerators, so that an intensity of heat is obtained, which, unless moderated on purpose, would fuse furnace and all exposed to its action.

The products of combustion are so completely deprived of the heat they brought out of the heating chamber K, by passing among the regenerator bricks, that the heat in the chimney flue is seldom sufficient to singe wood; the economy is therefore due to the fact that little or no heat is thrown away up the chimney, as in the ordinary furnaces, and also to the perfect combustion of the fuel, which is evidenced by the total absence of smoke from the stack; whereas, in the common furnaces the combustion is so imperfect, that clouds of powdered carbon, in the form of smoke, envelope all manufacturing towns, and gases are allowed to escape with two-thirds of their heating power undeveloped.

The saving of fuel in these furnaces, as compared to the ordinary kind, ranges between 40 and 60 per cent. in weight, according to the fuel used. In many instances an additional saving can be made in the cost of the fuel by using inferior qualities, such as coal and coke dust, lignite, and peat.

The intensity of the heat, purity of the flame, and the absence of cutting drafts in the heating chamber, is of great advantage for all metallurgical operations, tending greatly to improve the quality of the produce, and occasioning a saving of about 5 per cent. in the waste of the metal treated in puddling and iron reheating furnaces, &c.

The peculiarities and advantages of these furnaces are, that gas fuel alone is employed, that perfect and entire combustion is obtained, and that the heat, which is usually allowed to escape up the chimney, is here stored up to be afterwards brought back to the furnaces.

Whilst on the question of the combustion of coals, and of smoke, allow me to draw your attention to a clever invention by Mr. Snook, of Manchester, which he calls an "Invigorator." The invention may briefly be described as an apparatus placed within the semicircle forming the upper portion of an ordinary register fire-grate, formed entirely of cast iron, and so constructed as to be readily applied to all existing grates known as of the register form. In experiments which have been made, it has been proved that, after lighting the fire, (the whole of the apparatus being closed so as to act as a blower,) a brisk, bright fire is produced in about four minutes. A large concave elliptical plate immediately over the grate bars, suspended on end pivots, is tilted over to an angle of about 70° , when it is seen that the back or concave portion of the plate, acts as a bright reflector, throwing out the heat rays into the room, instead of allowing them to pass up the chimney. Two horizontal plate doors, or louvres, above the reflector, are next opened, when the draft is found to be reduced to the smallest amount compatible with the continuance of combustion in the grate. The heat thrown out from the fire is considerable, and the fire itself forms a pleasant object to look at, having a warm, red glow, without either flame or smoke proceeding from it.

The next invention I wish to call your attention to is one, which, like that of Mr. Siemens', is calculated to render marked service to society. It is the production of motive power through the combustion of coal gas, and you will, I hope, appreciate the discovery due to Mr. Lenoir, if you will call back to memory the efforts which have been made for the last twenty or thirty years to generate power by employing the expansion which air or other gases undergo under the influence of heat as a substitute for steam—the long promised success and the unfortunate failures of Ericsson. What especially recommended the engines of M. Lenoir is their safety, for there is no danger of explosion; their cleanliness, for they require no fuel; their simplicity, which enable those who employ them to use them in any room, at any height, and at any spot where motive power may be required, for they have only to erect a little engine of one or two horse power, and whenever they require to use it, all they have to do is simply to bring into contact two poles of a battery, when the fluid so generated will traverse space, and convey motive power to the gas engine. Lastly, these engines are extremely economical in their working, for they consume only 70 feet of gas per horse power per hour; and assuming that 1000 feet of gas is worth 4s. 6d., the cost of working an engine of one

horse power will be about 4d. per hour. M. Lenoir's engine is very similar to the ordinary steam engine, having a cylinder, piston, crank shaft, and fly wheel. The following proportions of gas are admitted in the cylinder: One volume of coal gas mixed with twelve volumes of atmospheric air. This mixture is ignited by the electrical spark from a battery connected by wires at each end of the cylinder. The connexion being made and broken by the rotatory action of the crank shank, the expansive force necessary to move the piston of the engine is produced by the ignition of the gas, which not only produces steam and carbonic acid by their combustion, but by the heat generated increases their volume to a sufficient extent to force the piston to travel backwards and forwards, thus producing motion. The engine once fixed, the battery charged, and the gas turned on, it is ready for action, and as soon as the work required is completed, the gas is shut off, the engine stops, and the expense ceases.

The facility for employing Lenoir's engine in countries where coal is not easily attainable has been increased by substituting for coal gas a mixture of oxide of carbon and hydrogen, which can easily be procured on a commercial scale at a small cost by passing steam over heated charcoal, the water being decomposed, its hydrogen being liberated, and its oxygen combining with the carbon itself produces oxide of carbon, and the mixture of these gases is a cheap and good substitute for coal gas. Consequently, M. Lenoir's engines can be employed with great advantage in our British colonies and in South America.

(To be continued.)

For the Journal of the Franklin Institute.

Fire in a Cotton Mill from Electricity. By JAMES B. FRANCIS, C.E.

On the 21st of March last, at about 8.30 A. M., the overseer of the spinning room in the Appleton Mills in this city noticed a smell of fire, and, in the course of five or eight minutes, discovered it on the upper side of a timber, in a belt box in the story below that of which he has charge. It had made but little progress and was immediately extinguished. My attention was called to it about half an hour after the fire was extinguished.

The belt box is an inclosure at the end of the No. 2 Mill, in which run the main belts, carrying power from the main shaft in the basement to the stories above. Three sides of it consist of a light wooden frame covered with boards, the fourth side is formed by the end wall of the mill. It is of different dimensions in the different stories; in the story in which the fire occurred, called the weaving room, it occupies about 7 feet lengthwise of the mill, and about $19\frac{1}{2}$ feet crosswise. Two small water pipes, carrying off condensed water from steam pipes, pass through the belt box, maintaining it usually at a temperature between 80° and 90° Fahr. In the room outside of the belt box, the temperature at this season is usually between 70° and 80° .

I found the timber which had been on fire to be of white pine, about $7\frac{1}{4}$ inches square, having one end built into the brick wall, and the other end framed into one of the main floor beams; it lays horizontally and parallel to the face of a leather belt, $19\frac{1}{2}$ inches wide. This belt is driven by a drum 11 feet in diameter, having iron arms and wooden lagging, and making 92 revolutions per minute; consequently, the belt moves at the rate of 3179 feet per minute. The amount of power transmitted by this belt is estimated at 175 horse power, corresponding to a tension of the tight side of the belt of not less than $175 \times 33,000$
 $3179 = 1817$ pounds. The pulley driven by the belt is 6

feet in diameter and is entirely of iron; the peripheries of both drum and pulley are covered with leather. The belt is made of two thicknesses of leather cemented together, and is about three-eighths of an inch thick; it was slightly greased on the inside, seven or eight weeks before the fire, with a mixture of tallow and neats-foot oil.

The part of the belt near the timber was the slack side, running upwards, nearly vertically, and at the nearest point was about 8 inches from the timber, and when I first saw it, a constant stream of sparks was passing between the belt and the corner of the timber which had been on fire. The charred wood indicated that about 6 inches of the corner had been on fire, and that it had extended about an inch in width on the top of the timber, and about half an inch in width on the side nearest the bolt; neither the top nor side of the timber have been painted.

Opposite the middle of the charred surface, and nearly opposite the middle of the belt, and about $2\frac{1}{2}$ inches from the charred corner, an iron bolt, three-quarters of an inch in diameter, passes vertically through the timber, having a nut on the top, and the lower end connected with a chain, supporting the iron frame of a binder pulley to another belt, driven by the same drum. Whenever I have tried it, a small spark could be drawn by the finger from any part of this iron work.

As stated above, at my first examination, sparks were observed passing between the belt and the corner of the timber; the next day I observed that they were passing between the belt and the top of the bolt and nut, and not, so far as could be seen, to the corner of the timber. At my first examination the timber had just been wetted for the purpose of extinguishing the fire; the next day, on wetting it again, the sparks were observed to pass between the belt and corner of the timber, as at my first examination. I have frequently examined it since, and, when the belt was moving, have always found sparks passing between the belt and the top of the bolt and nut.

The electrical excitement in the Appleton Mills at the time of the fire was unusually great, as was shown by the brilliance and length of the sparks, and the force of the shocks to the body on coming near some of the belts. I have not observed sparks passing between the belt and timber when the latter was dry, as it undoubtedly was, when the fire originated. So far as I have observed, however, the electrical

excitement has not since been so great as it was on the day of the fire, and I can find no other probable cause for the fire, and the conclusion is irresistible that it was caused by electricity.

It is not unfrequent to find in the belt boxes of a mill an accumulation of dust and flyings of cotton or wool, covering everything not in rapid motion to a sensible depth. In this case the belt box was very clean, to which fact, perhaps, may be attributed the slow progress of the fire and the detection of its cause.

Electrical excitement, manifested by sparks, shocks, and the symmetrical arrangement of the fibres of cotton and wool, is so common in our cotton and woolen mills as to excite no remark; it is, however, very different at different times. It is frequently used to light gas; a person standing on the wooden floor, and presenting one finger to a belt from which he can draw sparks, and another finger to the gas as it issues from a metal burner, the gas is instantly lighted. When the electrical excitement is strong, the same thing can be done at a considerable distance by several persons holding each others' hands. It has never been observed here before, that any other substance than gas could be thus ignited. Since this fire, however, the agent of the Appleton Company has succeeded in igniting tinder, by the sparks passing between the belt and the top of the bolt, and I have since done the same thing.

Many fires have occurred in our cotton mills which could not be accounted for at the time; ample means are provided for extinguishing fire, if promptly applied, which they are likely to be when the machinery is in operation, when, of course, the work-people are at hand. So far as I have observed, electrical phenomena are exhibited in the mills only when the machinery or shafting is in motion. By the light of the late fire at the Appleton Mills, it appears probable that many other fires, which were totally inexplicable at the time of their occurrence, may be attributed to this cause.

The exhibition of electricity in our mills is usually greatest in very cold weather, when the atmosphere contains the least moisture. At the time of the fire above described, the weather was quite different, being mild and cloudy, with a slight drizzle of rain falling. About 3 inches of snow fell during the preceding night. At 6:30 A. M., when the mill started, the temperature out of doors was 30°, at 2 P. M., 40°.

Lowell, Mass., April 3, 1866.

Photographing on Copper.

A M. Mialaret-Becknell writes from Saint-Jean Baptiste, Louisiana, to the *Cosmos* of Paris describing a method of photographing on copper and etching the photograph produced. The method is, in brief, the following, and it may be worth while for amateurs to experiment with:

Take a perfectly smooth and thoroughly clean plate of copper, dry it perfectly and immerse it in a bath of—

Sulphate of copper,	.	.	.	125 grains.
Sea-salt,	.	.	.	75 "
Water,	.	.	.	2 ounces.

Acidify the bath with a few drops of any acid to prevent the formation of a pellicule which would stain the plate. After an immersion of from thirty to sixty seconds (or more, if desirable) the plate is freely washed with water and completely dried with an old piece of linen soft enough not to scratch the metal, then rubbed smartly with soft flannel until it presents a perfect polish. In this condition the plate may vary in tone from a vivid red to a violet. These operations may be performed in diffused light, but too much light should be avoided. Place the plate in a frame behind an engraving or a glass negative and expose to the sun. With a good light it will take from five to ten minutes. After this the plate may be preserved for some days without alteration, provided the weather be dry and it be not exposed to a strong light; but as it is very hygrometric it had better be fixed immediately upon withdrawing it from the frame. This is done by plunging it into hyposulphite of soda containing a few grains of chloride of silver. In a few seconds the red tones of the plate whiten, the shadows take a violet tone, which finally turn to black. Precisely at this instant the plate must be withdrawn from the bath and agitated rapidly in a basin of pure water. After which the black deposit which forms the shadows must be removed, unless you prefer to let it remain. In this case wash in much water and dry rapidly over an alcohol lamp with feeble flame. As the shadows are formed of a powder which the slightest rubbing removes, they can be preserved by a transparent varnish.

But if the plate is to be engraved chemically, the black powder must be removed as indicated above, the plate washed under a strong jet of water, and plunged without drying into the liquid selected as a mordant. On this point I have nothing definite to say. All substances which act violently and evolve gas must be avoided. The following formula has sometimes succeeded:

Nitric acid,	.	.	.	.	.	1 part.
Bichromate of potassa, (saturated solution,)	.	.	.	.	.	2 parts.
Water,	.	.	.	.	.	3 "

In this formula the nitric may be replaced by sulphuric acid. I varnish the back and edges of the plate and plunge it into enough liquid to cover it. When the liquid assumes a blue tint I add more without touching the plate, and I prolong the action one or two days, according to the temperature. I have tried iodine in combination with the bichromate or nitric acid; in this case it is better not to remove the shadows. With the first formula the engraving is in relief, that is, the plate is attacked only in those parts which are covered with silver; by galvanism a plate is produced in which the shadows are depressed. Iodine and other agents which attack the copper and leave the silver have, therefore, advantages, but the iodine is much slower in its operation. Or the plate may be engraved galvanically by attaching it to the positive pole of the pile and immersing it in a very acid solution of sulphate of copper. The plate must be laid horizontally

and the copper plate which serves as the negative electrode must be above it, otherwise the coating of silver will become detached. Or it may be attached to the negative pole, in which case the shadows will be coated with copper.

New Ice Machine.

From the Practical Mechanics' Journal, December, 1865.

A machine for the production of ice on a large scale has lately been tried at Paris with great success. Its peculiar feature is that, unlike all the machines whose action depends on the circulation of ether or ammonia, it requires no pump whatever. Its effect is produced by means of heat and the circulation of the vapor of amylic ether, (oxide of amyle.) The latter is obtained, as usual, by the action of sulphuric acid on amylic alcohol, or that derived from potatoes; and it is liquefied by transmission, at a pressure of from five to seven atmospheres, into a reservoir placed under the cylinder. After having returned to the state of gas and formed ice, when a cock is opened, it passes from this reservoir into the spiral ducts which surround the quadrangular reservoirs, which are filled with the water that is to be congealed, and are immersed in a solution of salt that will not freeze. After the ether has been vaporized in the spirals, it passes successively into three large cylinders containing sulphuric acid, by which it is dissolved. One portion of the ether, being contained in the concentrated solution, is ready to yield up vapor under the action of the heat afforded by the circulation of superheated steam. A second vessel is ready to absorb the ether vapor. The third is in a state of rest, and ready to give up its ether. A machine of this kind, calculated to produce about a quarter of a ton (200 kilos.) of ice per hour, has been constructed for the concentration of sea-water, for the purpose of extracting its soda, potash, and other salts. The application of refrigeration to the separation of substances held in solution has been attended with the best and most economic results, and is becoming more general every day. It has been used even in the separation of sugar from syrup. Water, in freezing, completely separates from anything which it holds in solution.

Nitro-glycerine for Blasting.

From the London Journal of the Society of Arts, No. 689.

The *Berg-und Hüttenmännische Zeitung* states, that, among other disadvantages of Nobel's nitro-glycerine, is the fact that it freezes at a temperature very probably above 92° Fahr. It is said that even at a temperature of 43° to 46° Fahr. the oil solidifies to an icy mass, which mere friction will cause to explode. It is probable, however, that the freezing point of the oil lies somewhat lower than is here stated, though as yet no exact determination of the freezing point of the oil has been

made. A newspaper from Hirschberg, in Silesia, gives a sad account of an accident, caused by the frozen oil exploding by friction. Nitro-glycerine is there being used in making a railway tunnel. It was kept in glass vessels, packed in straw, and placed in baskets, each vessel containing one-fourth to one-eighth of a hundred-weight of the oil. For several days the oil had been frozen. It was carefully handled, and pieces were separated by means of a piece of wood, and put into the bore-holes, and it was found that the frozen nitro-glycerine exploded quite as well as the fluid. One day an overseer at the shaft hit upon the unlucky idea of breaking into pieces with a pick a seven or eight-pound lump of the frozen glycerine. The blow caused the mass to explode, and the unfortunate man was blown up into the air, and fell back into the shaft, some forty or fifty feet deep, whilst two workmen, who were making cartridges a short distance from him, luckily escaped with slight injuries.

Simple Method of Preventing Boiler Incrustations.

From the London Chemical News, No. 317.

In a manufactory at Lorenzschacht they use water holding a little clay in suspension, and, after three months' work, find on the sides of the boiler only a little mud, which is easily scraped off. This mud is nothing more than the clay itself, which prevents the deposit of crust mechanically by keeping the particles of deposited matters apart.

The New Atlantic Telegraph Scheme.

From the London Civil Engineer and Architect's Journal, March, 1866.

On the 2d ultimo a meeting was held, at the London Tavern, of gentlemen interested in the question of laying the most efficient and economical lines of telegraphic communication between England and America and the Colonies, and the advantages to be derived from the adoption of Macintosh's system of constructing deep sea cables. The Earl of Shrewsbury presided.

Mr. Macintosh proceed to explain the advantages of laying a cable direct from England to the United States, *via* Falmouth and Cape Cod. The proposed route was divided by shallow water into four parts—Chaucer's Bank, Milne Bank, and Newfoundland Bank, so that in case of accident the cable should be readily recovered for repairs. The peculiarities of the Macintosh system of constructing telegraph cables consisted in using a new insulating material of superior efficacy to any known substance, which enables a rate of 80 per cent. more signalling power to be obtained than in the case of the late Atlantic cable. All external iron wire sheathing, whether alone or in combination with tarred hemp, as in the late Atlantic cable, and all

steel wire spiralled round the conductor, would be dispensed with, and thus one great source of danger and expense was avoided. The mechanical strength requisite for the cable was obtained for the materials employed in insulating its conductor, which material was applied in numerous coatings or films, under tension, and a pressure of several tons, so that all superfluous weight was avoided, and such an excess of strength was obtained that the cable would sustain twenty miles of its length in water; and three cables could be constructed by Macintosh's system for the price of one such as it was lately attempted to lay across the Atlantic. The conductor of Macintosh's cable consisted of a series of fine copper wires, laid longitudinally, and held together by the insulating material; the cable was constructed in one continuous length, without welds or joints, and, when finished, was at once the smallest, lightest, least expensive, and most effective submarine telegraph known; and, moreover, it could be laid with a decreased risk of failure by the adoption of Mr. Macintosh's compensation apparatus for paying out cables with an uniform tension in all weathers. The soundings of the proposed route were very favorable, the cable could be made very inexpensively, and its greatest safety would be in getting into the deepest possible water. He had not brought forward his project on the wreck of the Atlantic Company's scheme; for it was submitted to the Leeds meeting of the British Association, nearly eight years ago, in the section over which Mr. Fairbairn presided, and his opinion was that all deep sea lines should be made with a conductor and insulator alone. The result of experiments already made shows the weight and capabilities of equal lengths of the late Atlantic cable, and of Macintosh's cable in the following manner:

	New Atlantic.	Macintosh's.
Conductivity in lbs. copper, . . .	300 lbs.	300 lbs.
Weight of insulating material, . . .	400 lbs.	400 lbs.
Inductive resistance in lbs. of gutta percha, . . .	400 lbs.	2000 lbs.
Diameter of cable, . . .	1 $\frac{1}{16}$ inch.	$\frac{1}{2}$ inch.
Weight per nautical mile in air, . . .	35 $\frac{3}{4}$ cwt.	6 cwt. 28 lbs.
Weight per nautical mile in water, . . .	14 cwt.	1 $\frac{3}{4}$ cwt.
Specific gravity, . . .	2.1	1.3
Breaking weight, . . .	11,000 fathoms.	17,000 fathoms.
Weight of 2300 nautical miles of cable, . . .	4111 tons.	718 tons.

From the above statement it will be seen that 2000 lbs. of gutta percha are only equal, for purposes of insulation, to 400 lbs. of Macintosh's compound, and the respective cost of the materials per pound is at least three to one in favor of the compound.

Mr. Macintosh said he could lay his cable down for £100 per mile, and he had made that offer to the Atlantic Company. If they persisted in their old course he had no doubt that another line would be laid down long before their line could be completed.

Captain Selwyn wished to know what sort of cable could be constructed for £100 per mile, and what would be the rate of speed? Would the cable be of the same length and with the same speed, or of greater length with the same speed?

Mr. Macintosh said the cost of the line to Newfoundland would be £100,000, and, with the same sized conductor, he could get at least 80 per cent. more signal power.

Captain Selwyn regarded with interest the development of a new material of so much promise. He believed that the statements of the inventor as to the advantage of the material could be proved, and he considered it was as applicable to underground electric telegraph lines as submarine cables. The route proposed by Mr. Macintosh was one in which there was no deep water for any great length. The distance to the first sand-bank was 900 miles, the next distance was 500, then came another 500, and then one of 430. In no case was the depth more than from 100 to 200 fathoms, so that the cable might be easily recovered if broken, and the risk to the shareholders was consequently diminished under any circumstances to 900 miles, which was the greatest loss it could incur. The Northern route had also the advantage of being divided into sections, but it had the disadvantage of having nine shore ends, and all electricians knew that shore ends were the great difficulty.

Captain Davis, as a nautical man acquainted with laying deep sea cables, would prefer taking the responsibility of laying three of Mr. Macintosh's cables to one of the Atlantic Telegraph Company's cables. He remarked that, as there was nothing to pay for concession, the advisability of forming a company to carry out the scheme was well worthy of consideration.

The chairman inquired whether Mr. Macintosh had any certificates as to the electrical condition of the cable? Mr. Macintosh replied that he had those Mr. Desmond Fitzgerald and Prof. Miller.

After a lengthened discussion, relative to the various materials employed for insulation, Mr. Harry Lobb moved the following resolution: "That, having heard Mr. Macintosh's statement, this meeting expresses confidence in the advantages of his system, and of its applicability as a means of direct telegraphic communication with America and the Colonies."

Captain Symonds seconded the resolution, which was carried unanimously; and it was agreed that another meeting should be held for the purpose of further considering the matter.

Incrustation of Boilers.

We accidentally omitted to notice at the proper time the receipt of a very interesting report by Prof. Chandler of the School of Mines, New York, "On the Water used for Locomotives on the New York Central Railroad and on Boiler Incrustations." The report contains carefully elaborated analyses of waters from seventeen different sources, and the summary of this part is made in the following excellently arranged table:

Composition of Waters now supplied to Locomotives.

STATIONS.	CORRODING CONSTITUENTS.						INCORRUSTING CONSTITUENTS.						INCORRUSTATION PREVENTIVES.		ORGANIC MATTER.	TOTAL.
	Chloride of Potassium.	Chloride of Sodium.	Chloride of Magnesium.	Sulphate of Potassa.	Sulphate of Soda.	Sum.	Sulphate of Lime.	Carbonate of Lime.	Carbonate of Magnesia.	Oxide of Iron.	Silica.	Sum.	Carbonate of Potassa.	Carbonate of Soda.		
Syracuse, Onondaga Creek, .	0.32	2.14			0.98	3.44	10.68	7.25	4.31	0.06	0.28	22.58			0.34	26.36
" Hydrant, .	0.24				0.07	0.38	16.71	6.84	3.69	0.06	0.25	27.55			trace	27.93
Warner's, .	1.91				1.81	3.72		7.17	3.63	0.11	0.37	11.28		6.09	0.37	23.63
Memphis, .	0.29	0.26			0.36	0.91	10.12	6.75	4.41	0.09	0.31	21.68			0.18	22.77
Jordan, .	0.33	0.76			0.62	1.71	4.02	5.03	2.30	0.03	0.09	11.47			0.06	13.24
Port Byron, .	0.39				0.32	1.08	0.01	5.43	1.57	trace.	0.16	7.17			1.28	9.53
Savannah, .	0.59				0.07	0.69	11.93	5.04	0.10	0.56	0.58	17.63			1.52	20.50
Clyde, Spring, .	0.14				0.18	0.45	9.66	4.40	6.07	trace.	0.80	14.30			1.88	18.28
" River, .	0.52	0.37			1.21	2.10	4.40	4.38	3.34	trace.	0.18	11.07			1.40	13.10
Lyons, .	0.29				0.71	1.03	3.17	9.15	5.98	0.02	0.30	18.73			2.16	22.07
Newark, .	0.47	0.38			0.32	1.17	3.19	8.41	5.98	0.02	0.17	33.39			1.46	36.28
Palmyra, .	0.76				0.67	1.43	18.81	7.68	2.23	trace.	0.48	10.53			0.80	12.04
Macedon Swamp, .	0.14				0.18	0.71	0.14	5.07	1.03	0.01	0.20	15.06			1.14	19.39
Fairport, .	0.34	0.69	2.16		0.39	3.19	8.72	16.92	8.88	0.10	0.90	33.26			1.60	42.17
Rochester, North Street Well, .	0.96	4.82	1.53			7.31	6.46	4.64	2.06	0.09	0.90	10.85			1.64	13.67
" Genesee River, .	0.28	0.05			0.85	1.18	3.16	4.60	1.81	0.05	0.18	8.80			1.24	11.15
" Canal, Round House, .	0.33	0.17			0.61	1.11	2.16									
Average, .	0.49	0.57	0.22	0.16	0.49	1.93	5.39	7.47	3.75	0.05	0.39	17.05	0.13	0.36	1.10	20.57

The numbers represent grains per gallon of 231 cubic inches.

And the incrustations are classified as follows:

1. Hard, compact, and crystalline, formed of numerous thin layers, and consisting of from 30 to 75 per cent. of sulphate of lime, associated with carbonate of lime, basic carbonate of magnesia, (2 Mg O, C O_2 ,) etc., (Analyses 1 to 6.)

With a single exception all the locomotive incrustations were of this character, as were also most of those from stationary boilers. The incrustations from marine boilers belong to this class, consisting almost entirely of sulphate of lime.

2. Loose and friable, not at all crystalline; in thick masses, not in well-defined layers, composed chiefly of carbonate of lime, (Analyses 7 and 8.) Only two specimens of this variety were met with, both from stationary boilers. They are evidently deposited from water containing very little sulphate of lime.

3. Consisting of a fine powder or mud. Noticed in only two instances; in one case in a locomotive, in the other in a stationary boiler. In composition the two specimens differ; one consisting chiefly of carbonate of lime and magnesia, the other containing 30 per cent. of sulphate of lime, (Analyses 9 and 10.)

A dissertation on the formation of incrustations and the various methods of prevention follows, in reference to which the following analysis of water from boilers using different methods of prevention is interesting, but would be much more so had an experiment been instituted using the same water in each boiler.

	1. No. 101.	2. No. 106.	3. No. 113.	4. Stationary, Machine shop, Syracuse.
Distance run, . . .	700 miles.	416 miles.	416 miles.	
Road, ...	direct.	Auburn.	Auburn.	
Preventive used, . .	bran.	bran, 2 buck- ets.	nothing.	potatoes, one peck.
Reaction, ...	neutral.	neutral.	neutral.	alkaline.
Sulphate of lime, . .	17.88 grs.*	9.53 grs.*	39.89 grs.	49.82 grs.*
Carbonates of lime and magnesia, ...	trace.	trace.	trace.	trace.
Chlorides, etc., . . .	56.76 grs.	19.38 grs.	52.95 grs.	37.42 grs.
Organic matter, . . .	9.83 "	8.86 "	13.99 "	12.59 "
Nitrates, ...	trace.		trace.	faint trace.
Total, per gallon, . .	83.97 grs.	37.77 grs.	106.83 grs.	99.83 grs.

The following are the practical conclusions of the report:

"In conclusion, I would advise—

1. The use of the purest waters that can be obtained; rain water, wherever possible.

2. Frequent use of the blow-off cock.

3. That the boilers never be emptied while there is fire enough to harden the deposits.

4. Frequent washing out.

* These figures are probably too high, as they are calculated from the sulphuric acid, a portion of which probably exists in the form of alkaline sulphates.

5. Experiments on the efficacy of zinc, lime water, carbonate of soda, carbonate of baryta, chloride of ammonium, some substance containing tannic acid, linseed meal, and the electro-magnetic inductor."

On the Specific Gravity of Mercury. By BALFOUR STEWART, M. A.,
LL. D., F. R. S.

From the London Chemical News, No. 325.

Some time since, in connexion with a research on the fusing point of mercury, several observations were made* at Kew of the specific gravity of this fluid. A specific-gravity bottle was used for this purpose, and it was washed, in the first place, with sulphuric acid; secondly, with distilled water; and thirdly, with alcohol; when this was done it was found to contain mercury without any air-specks or any diminution of that metallic lustre which pure mercury exhibits when in contact with a vessel of clean glass. Three different specimens of pure mercury were used, and were separately weighed in the specific-gravity bottle at 62° Fahr. The following results were obtained:

	Weighed in Air, Grains.
Mercury from the cistern of the old Kew standard barometer, filling the bottle, weighed at 62° Fahr., ...	13591.36
Mercury from the cistern of the new Kew standard barometer, weighed at 62° Fahr., ...	13591.66
Mercury used in experiments with air thermometer weighed at 62° Fahr., ...	13591.96

The mean of these will be 13591.66 grains. It was found that the specific-gravity bottle had an internal volume equal very nearly to 4 cubic inches, and assuming that a cubic inch of air weighs 0.31 grains, then the air displaced by the liquid filling the bottle would weigh 1.24 grains. In like manner the air displaced by the Kew standard weights (specific gravity 8.2) would have the volume of 6.6 cubic inches, and would weigh 2.04 grains. From these premises we find that the real weight of the mercury *in vacuo* would have been 13590.86 grains. Again, the amount of water which the same bottle held at 62° Fahr. weighed in air 1000.52 grains. Here the air displaced by the bottle is, as before, 1.24 grains, while that displaced by the weights is only 0.15 grain. From this we find that the real weight of water filling the bottle at 62° Fahr. would be *in vacuo* 1001.62 grains. We have thus

True weight of mercury filling the bottle at 62° Fahr. = 13590.82 grains.
True weight of the same volume of water at 62° Fahr. = 1001.62 "

And hence the specific gravity of mercury at 62° Fahr., as compared with water at the same temperature, will be 13.569 nearly. Again, if we assume the correctness of Regnault's table of the absolute dilatation of mercury, and also that of Despretz's table of the absolute dilatation of water, we shall find that the weight at 32° Fahr. of a volume of mercury weighing 13590.86 grains at 62° Fahr. will be

$$13590.86 \times 1.00298 = 13631.361 \text{ grains.}$$

Also, the volume at 4° Cent., or 39·2° Fahr., of a volume of water weighing at 62° Fahr. 1001·62 grains will be

$$1001·61 \times 1·0011437 = 1002·766 \text{ grains.}$$

Hence the specific gravity of mercury, according to the French method of determining it, will be

$$\frac{13631·361}{1002·766} = 13·594.$$

A determination by Regnault gives 13·596. These two results agree very nearly with one another; and this agreement tends, not only to verify the correctness of Regnault's determination, but to show that Regnault's table of the dilatation of mercury and Despretz's table of the dilatation of water agree together; a remark that had been previously made by Dr. Matthiessen in a paper which he recently presented to the Society.

Proc. Royal Society.

M. Athanase Dupré calculates, for the Academy of Sciences of Paris, that a cube of water, having a side equal to one thousandth of a millimetre, (or about six one hundred billionths of a cubic inch,) contains more than 125,000,000,000,000,000,000 molecules of that valuable compound. If any one doubts this conclusion let him show it to be false by a fair count.

M. Simonin reports that the climate of San Francisco (to which he or the printers of the *Comptes Rendus* of the French Academy of Sciences assign the latitude of 27° 40') is colder in summer than in winter; and that the coldest period of the twenty four hours is from noon until three o'clock. Whether this is also the darkest portion of the twenty-four hours he does not state.

Preservation of Vinegar.

From the London Chemical News.

It was an observation made by Scheele, but the fact has recently been published as a new discovery, that ordinary brown vinegar will keep bright and clear for any length of time if heated to the boiling point for a few minutes.

FRANKLIN INSTITUTE

Proceedings of the Stated Monthly Meeting, April 18th, 1866.

The meeting was called to order with the President, William Sellers, in the chair.

The minutes of the last meeting were read and approved. The minutes of the Board of Managers were reported.

At the meeting of the Board of Managers, held on the 11th inst., donations to the library were received from the Royal Society, the Royal Institution, the Royal Geographical Society, the Chemical Society, the Zoological Society, the Institute of Actuaries, and the Society of Arts, London, England; the Royal Irish Academy and Robert McDonnell, Esq., Dublin, Ireland; La Société d'Encouragement pour l'Industrie Nationale, Paris, and la Société Industrielle de Mulhouse, France; the K. K. Geologischen Reichsanstalt, the Oesterreichischen Ingenieur-Vereins, Vienna, Austria; the Canadian Institute of Toronto, Canada; Prof. A. D. Bache, the U. S. Survey, Dr. Charles M. Wetherell, and Frederick Emmerick, Esq., Washington, D. C.; Alfred P. Boller, Esq., City of New York; and from Profs. John F. Frazer and John C. Cresson, of Philadelphia.

In compliance with the Report of the Committee on Science and the Arts, the Board awarded to Mr. Alfred C. Jones the Scott's Legacy Premium and Medal for his invention of a friction coupling.

Seven gentlemen were elected members of the Institute by the Board.

The Standing Committee on the Cabinet of Arts and Manufactures reported the election of James H. Cooper as their Chairman, and the adoption of a system of classification for specimens. The other Standing Committees reported their minutes.

The Report of the Resident Secretary on novelties in Science and the Mechanic Arts was then read, as follows:

SECRETARY'S REPORT.

Cork Springs.—In connexion with new mechanical applications we would call your attention to the use of cork in place of india rubber, as a support for freight cars and like heavy vehicles. One would not be led by any means to predict the efficiency of cork in this connexion, from ordinary impressions of its properties. The cork used for these springs is of the commonest description, harsh, hard, and full of fissures. It is cut into disks of about eight inches diameter, each pierced with a central hole. Previous, however, to cutting, it is soaked in a mixture of molasses and water, which gives it some softness and renders it permanently moist. A number of these cork disks are placed in a cylindrical cast iron box, a flat iron lid or disk is placed over them, and by hydraulic pressure is forced down so as to reduce the thickness to one-half. A bolt is then run through box, corks, and cover at the centre, and a nut being screwed on this, holds all in place, when the press is relieved, and the box of compressed cork, disks, or cork-spring is ready for use.

One of these springs, placed in a testing machine, under a weight of 20,000 lbs., shows an elasticity suggestive of compressed air in a condensing pump. One would expect, from the appearance of the material, that, under heavy pressure, it would be pulverized or split into shreds, especially if this pressure was assisted by violent shocks; but in fact no such action takes place.

A pressure which destroys india rubber, causing it to split up and

lose its elasticity, leaves the cork unimpaired, and, with the machinery in use, it has even been impossible, with any pressure attainable, to injure the cork, even when areas of but one inch were acted upon.

(In connexion with this subject, the President, Mr. Wm. Sellers, remarked, at the conclusion of the Secretary's Report, that he had for some five years, employed a forging machine in which a spring of the form and material above-described was used and subjected to continual and violent shocks, and that its performance had been most thoroughly satisfactory, with no signs of deterioration.)

Howard's breach-loading sporting rifle was then exhibited. Its shape was exceedingly simple and compact, and capacity for rapid manipulation obvious.

Heyl's process for temporary binding or filing of papers, manuscripts, &c., was then explained and illustrated by specimens. In this system, two or three holes are cut with a small circular punch in the "fold" of each signature. At each of these a "binding-tag," (or half circle of paper with a loop of cord incorporated so as to leave only an eye projecting from the middle of its straight side,) is attached by gum already applied, so that the eye projects through the punched hole. Any number of signatures may then be strung together on "laces" run through these eyes, and these laces may be secured to appropriate fastenings in port-folios, between binding-boards, or the like.

Artificial Stone.—Among other valuable works transmitted to the Institute by Mr. James Swaim, now resident in Paris, is a pamphlet on the manufacture of artificial stone or beton, according to the plan devised by M. F. Coignet, accompanied by several large sheets containing drawings of columns, capitols, mouldings, and architectural ornaments, which can be supplied to order. In view of the extensive applications and yet more extensive applicability of this material, all accounts of its use are of value to us. The points of peculiarity about the system mentioned above, are the relative dryness of the materials, their fine division, complete incorporation by trituration, and final compacting by the blows of heavy machinery.

The substances employed are, as with beton generally, sand, stone, hydraulic cement, &c.

In the process as conducted, the material is in some cases, forced into small stationary moulds, by which blocks, mouldings, and the like, of stone are produced; while, in other instances, the material is driven into adjustable moulds arranged on the site of the work to be erected, and these being moved and extended as the construction advances, a monolithic structure is produced, having for many purposes great advantages over any other sort of architecture.

It appears that there have been thus constructed in Paris about sixteen miles of aqueducts and sewers, the foundations of an extensive depot for the Railway "Du Nord," the new prison of the Madelonnettes, and also the entire building for the Municipal Barracks covering an area of 22,000 square feet, and the tower of a church (of Vesinet) 130 feet high. Many cisterns for water, for gas-holders, &c., have also been built in this manner with entire success.

In a former report, Vol. L., page 66, mention was made of many extensive structures, such as dry-docks, break-waters, &c., which had been constructed with similar material.

Astronomy.—Prof. Huggins observes that the small stars constituting the trapezium in the nebula of Orion are very variable in their brilliancy, and suggests that they may be physically connected with this nebula, and since the latter has been proved to be of a gaseous and not stellar constitution, and by consequence to be at no great distance, much may be learned about its nature by a study of these variations.

An extended comparison of the Kew heliographs, which, by the way, are now all taken by Miss Beckly, daughter of the mechanical assistant, it would appear that the absorptive action of the sun's atmosphere upon his light rays, which causes a notable loss of strength in the photographs around the edges of the disk, is affected by the position of the planet Venus through her attractive effect upon the sun and his atmosphere.

Optics.—*Reflectors of Silvered Glass.*—Some improvements have been made in these instruments by Mr. John Browning. The most important are a plan of suspending the small diagonal reflector or prism by three fine wires in place of a single stout arm, and in protecting the mirror from the action of the atmosphere by a cover of plate glass. The cheapness and power of these instruments is drawing much attention to them.

Nichols' Prism, (New Form.)—MM. Hartnack and Prazmowski have exhibited before the French Academy, Nichols' prisms of remarkably large field, and with other advantages, such as avoidance of the loss of light occasioned by reflection from oblique surfaces.

These prisms are described as follows: The natural rhomb of Iceland spar is cut by a plane perpendicular to its axis in place of one passing through that axis, as in the usual form. The cut surfaces are then polished and cemented, in their natural positions, with Canada balsam or linseed oil, their ends being cut off so as to form angles of 79° or of 73.5° with the cut first mentioned, according to the cement used, as above stated.

Glass Mirrors plated with Platinum.—In a late number of the *Bulletin* of the Society for the Encouragement of National Industry, (French,) we find an extensive report on a new process for plating mirrors, which we briefly noticed some time since. The process has so many original features, and so many possible applications that an abstract of its chief points will be valuable.

One hundred grains of pure platinum are dissolved in aqua regia, and the chloride formed is evaporated to dryness, with care to avoid decomposition. This is pulverized, and to it is added essence of lavender, at first slowly, but when the temperature begins to rise, rapidly, until 1400 grains have been so used. The solution is allowed to settle for some days, is decanted and again allowed to settle. There are then taken 25 grains of litharge and 25 grains of borate of lead. These are thoroughly ground with 8 or 10 grains of essence of laven-

der, and then mixed with the platinum solution just described, which is then spread in repeated coatings with a brush upon the glass previously polished and well cleaned.

The varnish, as we may call it, is then allowed to dry spontaneously, and when quite dry the plates are set vertically in a muffle and heated to the required temperature for the decomposition of the mixture and the fusion of the flux.

Some of the advantages of this process are as follows: Any sort of glass may be employed, no matter what its color or irregularity of structure, provided one surface only is level and polished. The reflecting surface being on the outside, no confusion is made, as by the reflection in the common mirror from two surfaces.

The metallic particles are protected by the flux from all atmospheric influences. The reflecting surface is made up of metallic particles, and thus, though the mirror is an excellent reflector, it is also transparent in some degree.

Electro-magnets with uncovered Wires.—In another number of the publication above mentioned, we find in full Du Moncel's report upon the use of uncovered wires for electro-magnets. From this it appears that when currents of low intensity but large quantity are employed, such magnets have a notable advantage over others wound in the usual manner. They may thus be employed with good result for clocks, bells, and telegraphic instruments operated by local batteries. Where intense currents are employed and the resistance is great, as in long coils of fine wire, the uncovered coils are inferior in efficiency to those made with insulated wire. The uncovered coils have also the great advantage of freedom from the extra-current which, producing a bright spark at each rupture of contact, is a fruitful source of destruction to the commutators, interrupters, &c., so much employed in most magnetic machines.

Substitute for Nitric Acid in the Bunsen Battery.—Attention was called some months since to the advantages offered by a mixture of bichromate of potash, water, and sulphuric acid in the Bunsen battery. Extended experience has led us to modify the recipe then given, while it has greatly raised our opinion of the value of this material. We now find the best proportions to be as follows: To one gallon of water, one pound of *pulverized* bichromate of potash and $2\frac{1}{2}$ lbs. of commercial oil of vitriol. With this mixture we have obtained effects fully equal to those produced by nitric acid, with a gain from absence of fume, only to be appreciated by those familiar with the working of large batteries.

Iron Battery with same.—An extensive series of experiments has convinced us that this mixture is not applicable in this case. The fluid, as in the above recipe, gave an excellent current for a few minutes, after which the iron began to be attacked and the current fell off. A solution with no excess of sulphuric acid was then tried, but this gave a current too feeble to be of value, and, increasing the proportion of acid, it was found that a good current was only obtained when the liquid was capable of attacking and did soon attack the iron.

It would seem that as soon as sesquioxide of chromium is formed by the action of the battery, it makes, with the iron, a local circuit in which the latter is the positive or dissolved element. Going to the other extreme and using concentrated oil of vitriol, in which bichromate of potash was dissolved, an equally unfortunate result was encountered, the battery giving no force until such dilution as caused an attack of the iron was reached.

Chemistry.—*Etching on glass with a dead surface* may be effected with the following fluid mixture, which may be applied more certainly and conveniently than the gaseous hydrofluoric acid which has heretofore been the only means for obtaining this effect. Water, 1000 grains; crystallized fluorhydrate of fluoride of potassium, 250 grains; sulphate of potassium, 140 grains; muriatic acid, 250 grains.

By Solution in an equal weight of water, sulpho-cyanide of ammonium will lower the temperature from 60° to 10° Fahr.

A Delicate test for Iodine and Bromine is said to present itself in petroleum, to which these substances in very minute quantities communicate a distinct tint.

Good Crucibles for Melting Steel, rendering it less liable to blister, may be made from magnesia consolidated by pressure, according to M. Caron; and M. Balard, for like reasons, suggests the use of magnesia bricks in puddling furnaces.

A Process for the Manufacture of Sulphuric Acid without leaden chambers is described at some length in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*. Its prominent feature is the use of numerous earthenware columns filled with fragments of coke, through which the sulphurous fumes are caused to pass while nitric solutions are dripping down, being constantly returned to the summit by pumps. The plan in its general features is by no means new. Heretofore such arrangements have not proved successful on account of the great amount of nitric acid lost as compared with that expended in the leaden chambers.

From a long course of experiments conducted some years back, we have reason for believing that such a plan as the above is rendered much more efficient if a very tall column is employed, the lower part being warmed by a steam jacket, and the upper part cooled by any convenient means.

Cattle Plague and Carbolic Acid.—In the recommendations drawn up by the Royal Commissioners on the subject of the cattle plague, the greatest stress is laid upon the use of carbolic or cresylic acid, which, mingled with water, is to be used for washing, sprinkling, and sponging. Next to this is ranked sulphurous acid, obtained by burning sulphur on the premises, and, last of all, chloride of lime, which, in this respect, seems to have almost lost its character as a disinfectant.

After the conclusion of the Secretary's Report, Mr. Lippman explained his plan for the use of oblique-headed spikes and nails.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary*.

A Comparison of some of the Meteorological Phenomena of MARCH, 1866, with those of MARCH, 1865, and of the same month for FIFTEEN years, at Philadelphia, Pa. Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½' N.; Longitude 75° 11¼' W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	March, 1866.	March, 1865.	March, for 15 years.
Thermometer—Highest—degree, .	72·00°	76·00°	78·50°
“ date, .	15th.	21st.	3d, '61.
Warmest day—mean,	62·00	64·50	66·00
“ date, .	15th.	16th.	3d, '61.
Lowest—degree, .	26·00	24·00	4·00
“ date, .	18th.	11th.	10th, '56.
Coldest day—mean,	28·50	31·67	11·50
“ date, .	26th.	11th.	16th, '56.
Mean daily oscillation.	13·84	13·97	14·67
“ “ range, .	7·37	6·72	6·54
Means at 7 A. M., .	37·18	42 03	35·95
“ 2 P. M., .	45·43	52·40	46·86
“ 9 P. M., .	40·85	46·16	40·55
“ for the month,	41·15	46·86	41·12
Barometer—Highest—inches, .	30·199 ins.	30·210 ins.	30·522 ins.
“ date, .	1st.	1st.	3d, '52.
Greatest mean daily press.	30·156	30·148	30·445
“ date, .	1st.	1st.	11th, '52.
Lowest—inches, .	29·485	29·185	29·158
“ date, .	16th.	22d.	17th, '54.
Least mean daily press.,	29·538	29·241	29·241
“ date, .	16th.	22d.	22d, '65.
Mean daily range, .	0·161	0·188	0·191
Means at 7 A. M., .	29·893	29·825	29·844
“ 2 P. M., .	29·822	29·777	29·786
“ 9 P. M., .	29·862	29·826	29·824
“ for the month, .	29·859	29·869	29·818
Force of Vapor—Greatest—inches,	0·438 in.	0·507 in.	0·549 in.
“ date, .	15th.	16th.	18th, '59.
Least—inches, .	·066	·076	·023
“ date, .	17th.	6th.	5th, '58.
Means at 7 A. M., .	·173	·208	·165
“ 2 P. M., .	·190	·227	·180
“ 9 P. M., .	·193	·227	·182
“ for the month,	·185	·221	·176
Relative Humidity—Greatest—per ct.,	95·0 per ct.	96·0 per ct.	100·0 per ct.
“ date, .	21st.	9th. and 31st.	often.
Least—per ct.,	29·0	24·0	16·0
“ date, .	30th.	18th.	31st, '60.
Means at 7 A. M.,	71·9	72·6	73·4
“ 2 P. M.,	57·8	53·8	53·4
“ 9 P. M.,	69·4	67·1	67·8
“ for the month	66·4	64·5	64·9
Clouds—Number of clear days,* .	8	7	9·6
“ cloudy days, .	23	24	21·4
Means of sky cov'd at 7 A. M.,	60·0 per ct.	62·6 per ct.	60·1 per ct.
“ “ 2 P. M.,	73·6	71·9	62·6
“ “ 9 P. M.,	53·9	58·1	46·7
“ “ for the month	62·5	64·2	56·5
Rain and melted snow—Amount,	2·035 ins.	4·875 ins.	3·268 ins.
No. of days on which rain or snow fell,	11	13	10·9
Prevailing Winds—Times in 1000,	N 58° 14' W 294	S 58° 40' W 154	N 70° 14' W 280

* Sky one-third or less covered at the hours of observation.

JOURNAL

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

JUNE, 1866.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

The Bourdon Pressure Gauge. By JOHN T. HAWKINS, U. S. N.

The rejoinder of the author of the original paper on the Bourdon Gauge, published in the *Journal* for April, attempts to show that the illustration given by me in my first reply was based upon a violation of certain settled principles of Mechanics. This attempt, it is evident from the arguments used throughout, is built upon, first, a misapprehension of the illustration; and, second, upon an assumption unwarranted in its application to this particular instrument.

He says: "The writer makes his grand *faux pas* when he assumes as established the following two remarkable points: 1. That in the same system of forces, when estimating their effects upon the same body, we are at liberty to take a different centre of reference for each force. 2. That the components of two forces will produce different effects from those of the original forces."

In the first place, it is not to be assumed that the line joining each pair of original forces is a rigid body, even though the diameter of the circular section of the tube be not increased; nor is the entire tube upon which the four original forces were supposed to act. If these forces produce motion within the body itself by their application at the points taken—whether we consider the line joining each pair of original forces or the entire tube the body—then the position taken was a correct one.

In my illustration the inner and outer boundaries of the tube were treated as separated bodies connected by the remaining material of the tube, that material being capable of extension, compression, and trans-

verse movement of its parts, as decided by the direction and intensity of the forces applied. If in the application of the original forces, or their components, the interior boundary suffered extension through its connexion with the exterior one, and the diameter of the circular section remained unaltered, the line joining each pair of original forces and the volume of the tube would both be increased; in which case, motion of the points of application must ensue, which is all that the "first principles of Mechanics" require.

That a curved tube without excess of internal pressure must, in order to preserve its volume, undergo a change from a circular to an elliptical section by being forcibly straightened, is but the converse of the fact that a similar tube with excess of internal pressure sufficient to preserve its circular form of section will, if forcibly straightened, be increased in volume, unless the forces applied tend to compress its outer boundary. It was the object of the illustration to show that the tube was thus straightened. Under these conditions a line joining each pair of original forces would no longer occupy the position of radius to either curve, and would, therefore, be increased in length.

In the second case, it was not attempted to show, nor can it be inferred from the illustration, that the components of two forces were to produce effects different from those of the originals, for the original forces may be shown to effect the same rotation about the two centres of reference, with the inner and outer boundaries considered as distinct bodies bound together by a substance capable of being distended and distorted transversely. The reason the assumed forces were resolved at all was simply to exhibit that, while they were not in a condition of equilibrium, so far as their effect in producing motion among the particles of the material of the tube was concerned, they were in reference to producing motion of the instrument as a whole. I therefore fail to see that it was so entirely unnecessary to thus resolve them, or that it in any way tended to confusion.

Again, in reference to my second figure, I did not "lose sight entirely of all intermediate arcs of metal." On the contrary, I not only held that in view, but, additionally, that the metal possessed a certain degree of lateral elasticity, which latter fact he seems to have entirely ignored, as if the material of which these tubes are composed was vulnerable only to transverse strains. He states that "this metal is not supposed to stretch between any of these points." I made no such supposition, nor can it be predicated upon either of my illustrations, except it be in a direction perpendicular to the axis of the tube.

I do not regard the case either of the copper steam pipe with short bends, the small pipes of the hydrostatic press, or the experiment with the rubber tubes and bulb, as anything of a "crucial test." In the first case, such pipes are always secured at both ends in such a manner as not only to prevent a separation of the ends, but also to resist any force exerted to rotate that portion of the pipe leading from the fixed end to the beginning of the curve about the fixed end as a centre, which must be done in addition to *producing curvature in the previously straight part of it.*

I certainly would not advance the idea that such tremendous effects

would be produced when I see the very moderate result of similar pressures in the Bourdon tube, with an elliptical section and one end free to move.

The second case is no different, for the pipes of a hydrostatic press are made very thick in order to sustain the enormous pressure, and this thickness is proportional to it. Its resistance to a change of form is, therefore, also proportional to the pressure.

In the experiment with the rubber tube and bulb, he admits that motion should ensue, if it were only what was due to an enlargement of its circular section, and yet there was no perceptible motion. This is a tacit admission, and, in fact, proves that the experiment was of too rude a nature to decide a question in which the motion resulting from the forces applied must be multiplied many times to render them readily observable, even under the most favorable conditions of the flattened Bourdon tube.

Whether the reasoning in my first reply was sound or not, I leave the reader to judge for himself. If, however, a "*faux pas*" has been committed, it is to be found in the charges made in the rejoinder referred to.

Deflexion of Beams.

From the London Builder, No. 1204.

Will you permit me to make a few observations with regard to the experiments on this subject recorded by Mr. Papworth in your number for the 17th inst. * having paid some attention to the problem in question. Referring to the edition of 1845, page 81, of "*Barlow*," I find that the author says: "Hence we conclude that the deflexion of a beam fixed at one end in a wall and loaded at the other, is double that of a beam of twice the length, supported at both ends and loaded in the middle with a double weight." But Mr. Papworth is incorrect in calling this "the result given from numerous experiments made with perfect apparatus by Barlow;" the whole of the formulas being obtained by mathematical *reasoning*, and not as the result of *experiment*, which *reasoning* has been shown by all later investigators to be inaccurate. Most of the formulas given by writers on the strength of materials are obtained by mathematical induction, and experiments are instituted in order to find the values of certain constants, (varying according to the *material* of which the beams are composed,) so as to make them applicable for practical purposes.

I would also call Mr. Papworth's attention to the table 73, pp. 110, 111, of "*Barlow*," in which experiments very similar to his own are recorded. The first set of beams are all "very dry," and have been "six years in store," (taking those only reported "sound.") Each is 2 inches square and projects 5 feet. The second set of specimens "were kept wet," and had also been "six years in store." The actual deflexions are not given, but on the previous page the mode of experimenting is explained, the beam being bent over a semi-circle of oak 6 inches radius. In the "very dry" beams the "arc received" is $3\frac{3}{4}$ inches average, and in those "kept wet" the average is $2\frac{1}{8}$ inches;

* See page 309.

so that the actual deflexion must have been at least twice as much in the former as in the latter. I refer to these experiments to show how necessary it is to take into consideration the *condition* of the timber at the time the experiment is made; and also that experiments on one or two beams are quite insufficient to settle the question.

The numerous experiments recorded by Barlow were made with a view of ascertaining the *breaking weight* of beams, so that the deflexions given are not such as can be calculated by for formulas; for, as Fenwick remarks, at page 82, "in practice only very small flexions are admitted," certain qualities being rejected in the investigation as being very small and unimportant when the deflexions are small, but which become appreciable when the deflexions are large, the real practical use of the formula being to ascertain what weight may be laid on a beam without producing perceptible deflexion. The only experiments given by Barlow which will allow of comparison with the formula are seen in table 70, page 106. These were made by Colonel Beaufoy, at Deptford Dockyard, on twenty-five pieces of Riga fir, all cut from the same tree, each piece being 2 inches square, and projecting 4 feet from the wall, and weighted at the outer end. The mean weight laid on was 98 lbs., and the mean of the deflexions of the twenty-five specimens was $1^{\circ} 22'$, "measured on a graduated arc of the same radius as the beam, viz: 4 feet." The vertical deflexion, therefore, is $48 \times \sin. 1^{\circ} 22' = 1.145$ inches. Now, the formula given

by Fenwick, page 86, (omitting weight of beam,) is, deflexion = $\frac{4 w l^3}{E b d^3}$,

where b , d and l are all in inches, and E is the *modulus of elasticity*, say 2,000,000, the highest number for fir.

From this formula we get deflexion = 1.355 inches, which is $\frac{2}{10}$ -inch more than the experiments give, the timber being, no doubt, of first-rate quality. Barlow remarks: "It appears from all these experiments that the deflexions are very nearly in the ratio of the weights, till about one-half, or a little less than one-half the weight, is laid on, after which they become more rapid, and very irregular." So that experiment shows the formula would not be correct in this case if w exceeded 98 lbs.

In experiments of this sort great care is necessary to have the beam firmly wedged into the wall, as described by Barlow at page 114, as the least play will nullify the results. The formula which Mr. Papworth quotes from "Gregory" is identical with that given by "Fenwick," only in the former the length is in *feet*, and in the latter in *inches*, and I is the moment of inertia of the section; so that the formula applies to all forms of section, and in the rectangle $I = \frac{1}{12} b d^3$. In calculating the deflexion of a beam fixed at one end, and loaded with a weight, w , at the other, $\frac{3}{8}$ of the weight of the projecting beam should be added to w .

E. WYNDHAM TARN, M. A.

Mr. Papworth's letter may render some service, if it lead practical men to make experiments on the deflexion of timber. Those whose

acquaintance with the calculus, and whose leisure may enable them to follow the elegant process by which deflexion (or rather the *law* of deflexion) is mathematically found, will not hesitate to affirm the correctness of the formulas given, and the conclusions drawn, by Mr. Tarn, (page 895 of your last volume,) quoting from Mr. Fenwick, conclusions no more peculiar to those gentlemen than the opinion that two and two make four. By *correctness* I mean, that if you grant the premises, you cannot escape the conclusion.

Of course, with a right formula we may have a wrong *modulus*; and here is a weak point. We want extensive, accurate, systematic experimenting, to get at something like reliable average *moduli* of elasticity for different descriptions of timber. Not but that, when all is done, there will remain wide scope for observation and practical judgment in the endless varieties of elastic strength that occur even in one and the same kind of timber.

Again, the formulas go on the assumption that the piece of timber is *perfectly uniform* in size and elasticity throughout, with no tendency to bind irregularly or to twist.

With regard to the beam having one end fixed in a wall, the fixture must be *absolute*, and this is not an easy thing to ensure.

If a piece of timber, such as your last correspondent describes, (page 309,) were supported in the middle, and a $\frac{3}{4}$ -cwt. hung at each end, 3 feet 6 inches from the support, and a mean taken of the deflexions where the weights hung, I think the experimenter would be in a better position to test the accuracy of the theorists.

To examine the first set of experiments reported by Mr. Papworth, and compare the results with theory, let us accept the fact that the piece of fir deflected $\frac{3}{10}$, or 1.05 of an inch, with $1\frac{1}{2}$ cwt. in the middle, and make this the basis of calculation.

Beam supported at both ends—

	Inches Deflexion.	
	Theory.	Actual.
With $1\frac{1}{2}$ cwt. at quarter distance, ...	0.59	0.60
With $\frac{3}{4}$ -cwt. " "	0.30	0.35

Beam supported and fixed at one end—

With $\frac{3}{4}$ -cwt. at D, ...	1.05	1.80
" " F, ...	0.44	1.08
" " E, ...	0.13	0.63
" " G, ...	0.02	0.25

The excess of deflexion, as observed, being 0.75 at D, 0.64 at F, 0.50 at E, and 0.23 at G. These excesses, being approximately as the distances from the support, suggest the idea of the support, or fixing down, having yielded or started, in some small degree, a thing not likely to occur were experiments made, as I suggest, with both ends loaded and the support in the middle.

If the observed depressions at G, E, F, and D were genuine *deflexions*, I trust your practical readers will bear with me when I submit that they would be as the cubes of distances of weight from support, or as

the numbers 64, 27, 8, 1. That such is far from the case, will appear on comparing the following figures :

Observed,	1.80	1.08	0.63	0.25
If as cubes of distances, would be	1.80	0.76	0.22	0.03

CHARLES E. CONDER.

Telemeters, or Instruments for Measuring Distances. By the late
ARCHIBALD H. BELL, M.A.

Concluded from page 309.

From the London Mechanics' Magazine, November, 1865.

I now come to the consideration of those instruments which have been designed to meet the requirements of a particular case, viz: that of batteries in elevated positions overlooking the sea. It will be clear to every one that this is a special case, having the peculiar advantage that we are enabled to make use of the vertical height of the battery above the water-level as our base, instead of being limited to the few feet which can be provided by instruments, such as we have just been considering, designed for general purposes. These instruments are, first, the Gibraltar instrument, proposed by Colonel Shuttleworth, R. A., in 1860, while in command of that station; second, the Malta instrument, erected in the Fort St. Elmo, the Castle of St. Angelo, and the Fort Figuè, at the time that General St. George was in command of Malta; third, an instrument invented by Captain Jerningham, R. N.; and lastly, an instrument of my own, which, for the sake of distinctiveness, I have called the hydroscope, and which, after a lengthened investigation, has been finally approved of and adopted into the service, it having been recommended by the Ordnance Select Committee "that a hydroscope be supplied to every battery, or group of adjacent batteries, of a height not less than 100 feet above the sea."

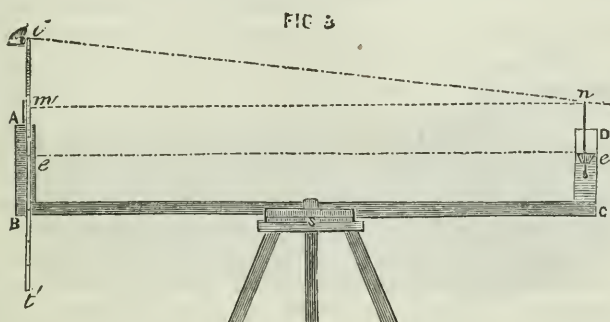
The Gibraltar instrument consists of a telescope, to which a graduated arc is attached, provided with a movable index arm, carrying a spirit-level, and is mounted on a light tripod stand. The telescope being laid upon the object, the index arm is moved until the spirit-level shows it to be perfectly horizontal; the angle of depression is then read on the graduated arc, and the distance of the object found by reference to a table calculated for the known height of the battery.

The Malta instrument is a massive semi-circular frame, of 3 feet radius, firmly fixed upon a masonry pedestal, and accurately leveled in all directions, in the centre of which works a vertical tangent scale, which is to be raised until the object at sea can just be seen over the rim of the semi-circle. The tangent scale may be either graduated with the angles, and reference be made from it to a table of distances, or the distances may be marked on the tangent scale itself.

Captain Jerningham's instrument consists of a plank of mahogany, 5 feet long, having a foresight at one end and a movable tangent scale at the other, and furnished at the centre with a spirit-level. Having leveled the plank first of all by little wedges, or whatever may be at

hand, the tangent scale is raised until the object at sea can just be seen over the foresight; the angle is then read on the tangent scale, and the distance determined by reference to a table calculated for the known height of the battery, which table, for convenience, is pasted upon the plank.

The following is a description of the hydroscope, which has been



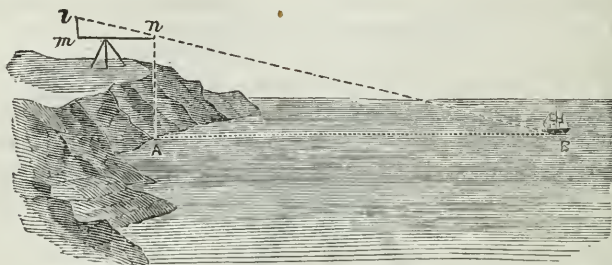
in constant use at Dover since August, 1862. It was made by a common tinman, at the cost of a few shillings, and it is only reasonable to expect that the instruments which are to be issued to the service will be in every way superior to the original, and obtain much better results than even those which have proved its practical value. (See Fig. 3.) BC is a piece of common galvanized iron gas-pipe, having attached to it, at each extremity, an upright rectangular tin tube AB and DC; the ends of the pipe at B and C are closed, but communication is open with the tubes AB and DC throughout from D and A. The pipe is clamped down by means of a small cap-square to a wooden bed S, which rests on a three-legged stool or on the top of a parapet. Into the instrument water is poured until the upright tubes AB and DC are about half filled. In each of these upright tubes there is a tin float, carrying, at right-angles to the line of the pipe BC, a small iron rod, having at the top a cross-bar of copper m and n. The floats are so weighted as to ensure the upper edges of the cross-bars being exactly level with each other when they float side by side in water. It will be evident, without further explanation, that, however the instrument be circled about upon its stand, the cross-bars m and n must always be perfectly horizontal. The tangent scale tt' slides up and down in a brass holder, which is confined in a groove of brass soldered on to the tube A, as shown in the engraving. This scale is of mahogany, square in section, with strips of sycamore inlaid on two of its sides, which are graduated to every 50 yards—one side to be used at high tide, the other at low tide.*

To use the instrument, traverse it round until it is in line with the object, then raise the tangent scale until the water-line of the object can just be seen over the top of the cross-bar n, through the cross-

* For other states of the tide, the mean between the two scales may be taken.

sight of the tangent scale. The distance is shown in hundreds of yards at the upper edge of the cross-bar *m*. Explanation of the theory is scarcely needed; the distance is to the height of the instrument above the water-level as the length of the instrument is to the length of the tangent scale. (See Fig. 4.)

FIG 4



Two instruments, one upon the Gibraltar and the other upon the Malta plan, were made by Messrs. Elliott, of the Strand, to the order of the Ordnance Select Committee, at a cost of £7 each, and were sent to Dover for trial in the spring of 1861. The Malta instrument being required to be portable, was constructed of a stout semi-circle of cast iron, and furnished with a spirit-level. The two instruments were placed in a battery 233 feet above low tide, and observations were taken with both of them by different officers of the Royal Artillery quartered there at the time. In thirty observations taken with the Malta instrument, at distances varying from 300 yards to 1402 yards, the mean error was 0.050 of the whole distance, or 41 yards in the average distance of 834 yards. In the same number of observations made with the Gibraltar instruments at the same objects, the mean error was 0.045 of the entire distance, or 37.53 yards. There was, therefore, but little difference between them in point of accuracy; but all the officers who used the instruments declared their preference for the Gibraltar instrument, as being the quickest and easiest of management. It was reported, however, that it required an adjusting screw for the index arm; and the instrument got out of repair while at Dover. When it had been put in repair, and the proposed adjusting screw added, the two instruments were sent to Gibraltar, where they were tested side by side in the Princess Caroline's battery, which is 557.803 feet above mean tide. They both gave good results up to 1893 yards, there being, as before, but little difference in point of accuracy; but the Gibraltar instrument still received the preference, the Malta instrument being found "unsteady and difficult to level." The time occupied in making each of these observations was not given, and it is difficult to compare the accuracy of the results with any observations taken in England, as the height of the battery above the sea is so much greater than any in this country. Captain Jerningham's

instrument was tried at Plymouth and also at Dover, at heights varying from 230 feet to 300 feet. It was found to measure distances with sufficient accuracy, but the leveling of the plank was attended with great difficulty and loss of time, unless there happened to be in the battery some level pedestal for its especial use; and the moving up and down of the tangent scale was apt to shake the instrument out of its proper level. The plank was also found to bend and warp by very slight exposure to the weather.

The hydroscope has, as I have said, been in constant use at Dover since August, 1862; it has been repeatedly tested at stationary and at rapidly moving objects, and its efficiency has been practically exhibited with 40-pounder and 7-inch Armstrong guns at small targets up to 3300 yards, from batteries varying from 150 feet to 280 feet above the sea. It was favorably reported upon by a regimental board of officers at Dover in 1862, and by Colonel Shuttleworth, commanding the Royal Artillery in the western district, after trial at Devonport, in May, 1863, and has now been adopted into the service upon the recommendation of the Ordnance Select Committee. This instrument gives instantaneously the distance in yards of an object at sea, however rapidly it may be moving, from any battery not less than 100 feet above the water-level. Its perfect simplicity precludes the possibility of any mistake being made in its use, and it may be used by an uneducated person after five minutes instruction. From a battery 100 feet above the sea, distances up to 2500 yards can be accurately measured with it; from batteries of from 150 feet to 250 feet above the sea, such as Folkestone battery, and the Martello towers along Shorncliffe camp, we could measure 3000 yards; and from batteries of 300 feet above the sea, and upwards, such as there are at Dover, Plymouth, Gibraltar, and many other of our fortifications, distances up to 5000 yards may be accurately measured.

It is, of course, impossible to lay down as an established rule what the practical accuracy of the instrument is to be considered, as this will vary with the height of the battery above the sea, and also with the eye-sight of the observer. At an altitude of 150 feet, a good gunner, with the aid of the hydroscope, will measure 2500 yards within 30 yards, more or less. In observations at the lower ranges, the principal cause of inaccuracy is the difficulty of distinguishing the precise water-line of the object, but any one accustomed to laying guns will usually find his most distant observation to come within 50 yards of the correct distance. The advantages which I claim for the hydroscope, over all other inventions hitherto proposed for the same purpose, are, the strength and simplicity of the construction, its rapidity in operation, and its cheapness of manufacture. It is confidently anticipated that these instruments will be supplied at one-quarter the cost of either the Gibraltar or the Malta instrument. The hydroscope levels itself, and gives the required result without any reference to tables, or any calculations being necessary. It is thus the only instrument which can estimate at each moment the varying distance of a rapidly moving object. The instrument is not liable to accidental injury, and

able. Mr. Bell says with regard to these: "We require to estimate distances on board ship, *where not only the object, but also the observer, may be in motion.*" This is certainly the most complicated case of all, and as to instruments which will meet it, the author remarks justly: "This requirement is one of the navy rather than of our own profession, but it is of equal public importance, and though there are many difficulties in this form of the problem, there is every reason to believe its solution to be quite practicable and that it will be some day effected." This difficult problem has found a satisfactory solution already, through the invention of the instruments of M. Hermann Gurlt, and of which it is now proposed to give a description. Mr. Bell is not quite correct in remarking that all telemetric methods and instruments depend upon one fundamental principle, and upon which all our efforts to estimate distances must be built, viz: that, knowing the base of an isosceles or of a right-angled triangle, we can ascertain its height by measuring the vertical angle, as we shall see that scalene triangles may be used for this purpose as well, supposing that there are other elements known by which their values may be ascertained.

One of the commonest methods of estimating at sea the distance between two ships, is to measure with the sextant the angle a of the supposed right-angled triangle (Fig. 1) ABE , in which $BE = a$ represents the height of the other ship's mast, which is supposed to be known. The distance AB or d is then found after the formula $d = a \cot. a$ by a very simple and easy calculation, for which purpose even tables may be prepared representing the value of d for the limited number of values a and a . This method appears to be very easy, but it is little commendable, as it admits of very considerable errors, and for the following reasons: The correctness depends, in the first instance, on the knowledge of the real height of the other ship's mast, which can only be guessed, and is consequently a source of great error. Besides, even if the real height were known, in case the ship rolls or is inclined leeward, the observer never knows how much of the real height he can see; and supposing the mast to be inclined leeward 39° out of the vertical line, the difference between the real and apparent height would produce an error as great as one-fourth of the distance. Besides the uncertainty of a , even the value of angle a is difficult to ascertain on board ship, as two points—say, the masthead and the part where it appears over the bulwark—must be simultaneously observed. Lastly, this method is not at all adapted for operations against coasts.

A second method is based upon the *exactly* known height of the observer in the rigging above the level of the sea. In Fig. 2, the distance AM or d of the other ship M , is ascertained by measuring from the elevated stand-point O , the angle λ which the two lines OM and ON form; the former being a line drawn from the observer's eye to the ship's water-line, the latter one to the horizon. As the angle AON is known for the different values of $AO = h$, *i. e.* length of base-line of the triangle AMO , the angle AOM or a is ascertained by deducting λ or NON from NOA ; and the triangle supposed to be right-

angled, the distance d is found from the formula $d = h \tan. \alpha$ for which tables might easily be calculated. Although this method is founded on a known instead of a guessed base-line, it is subject to several sources of errors, which affect its correctness considerably. It is evident that this correctness is much influenced by the correct observation of angle α , which, however, is hardly possible, as the observer has to lay his instrument simultaneously upon two objects, and as this angle is necessarily small from the limited height of the base-line h . To this we must add that even the base-line is influenced by the oscillations of the vessel, and its value consequently much varied, and that it is impossible to lay any instrument exactly upon the water-line of a ship at sea, and much less so upon the horizon. From all this it follows that this method must needs be very incorrect, and as it is not applicable whenever the horizon is not visible, that is, when covered by coasts, thick weather, powder, smoke, &c., it is evident that it is very little use at all.

A third method is based upon the same formula as the one just described, but it has the advantage of a constant base-line $AB = a$, (Fig. 3,) fixed along the deck of the vessel. At B is a sighting instrument, so arranged that its axis forms a right-angle with the base-line; and at exactly the same moment when the object M, either by turning the ship or by any movement of the object M itself, passes before the sight, another observer, stationed at A, measures the angle α , and the distance $d = a \tan. \alpha$ is then easily ascertained. This, theoretically, very simple and—owing to its long permanent base-line—much favored method is, however, in practice hardly applicable, as for every observation the vessel requires to be brought exactly in such a position that her base-line forms the desired and supposed right-angled triangle with the lines AM and BM, which, however, is not very easy to accomplish. Besides, it labors under the disadvantage that the observation can only be made at a certain moment, and does not allow any repetition. From this it will be seen that the telemetric methods hitherto in use at sea are extremely imperfect, and that any method or instruments which will permit of accuracy in measuring distances at sea, both for purposes of naval gunnery and of hydrographical survey, are a real desideratum. This difficult problem appears at last to have found its solution by the method and instruments of M. Gurlt, so that little remains to be desired. M. Gurlt's new method rests—like all other military and naval telemetric methods—upon trigonometric principles; but as it is based on the measurement of any scalene triangles by means of a very ingenious instrument, its application is far more manifold and accurate than that of any other at present known, and as it can be used when either the observer or the object, or both, are in motion without any loss of accuracy, it must be admitted to fulfil even the most sanguine expectations. In the triangle CDM , (Fig. 4,) the two distances d_1 and d_2 are ascertained from the known base-line $CD = \beta$ and the two adjoining angles α and β after the formulas $d_1 = \frac{c \sin. c}{\sin. \gamma}$

and $d_2 = \frac{c \sin. \alpha}{\sin. \gamma}$. The great superiority of this over all other methods consists in the exactly simultaneous observations of the two angles α and β , it being entirely indifferent whether they are right, obtuse, or acute, and in the use of a permanent, unchanging base-line. The method is simply carried into practice by measuring along the deck the constant base-line CD , and in placing at each end of it one of Gurlt's telemeters. The same object or part of an object, the distance of which from the base-line it is intended to ascertain, is then sighted with the telescope of each instrument, so that, following the motions of the object or those of the observer's vessel, it is always kept covered by the cross-hair centres of the instruments, when, at any given moment, both telescopes can be simultaneously fixed in their position through the action of two powerful electro-magnets, which are attached to each instrument and brought into play by a galvanic battery. The two observed angles α and β are then read, and they furnish the necessary elements for the calculation of the triangle sought. As this method must increase in accuracy with the length of the base-line, it is clear that CD should be made on board ship as long as possible, and as this length is practically unlimited on shore, it is evident that this method is of great value for the purposes of coast defence. Its very great accuracy, however, renders it most valuable for the hydrographical survey, which almost constantly has to solve the problem of the inaccessible distance, *i. e.* to find the distance from each other of two points M and M_1 (Fig. 4) which cannot be approached. It is only necessary to measure the triangles CMD and CM_1D to find the angle $\delta = \alpha - \alpha_1$ and $\delta_1 = \beta_1 - \beta$; and, from two sides and the enclosed angle $M M_1$ or m , is ascertained in the triangle $CM M_1$,

$$m = \sqrt{d_1^2 + d_3^2 - 2 d_1 d_3 \cos. \delta},$$

and in triangle $DM M_1$,

$$m = \sqrt{d_2^2 + d_4^2 - 2 d_2 d_4 \cos. \delta_1}.$$

In order, however, to save the trouble of calculation, which would require some little time, and to comply with one principal requirement of a good telemeter, which Mr. Bell justly says is its capability of being used with rapidity, and showing the result at a glance, M. Gurlt has invented another auxiliary instrument, the "constructor," by which the measured triangle can be reconstructed *en miniature* in a few seconds and its values d_1 and d_2 read direct from a graduation.

The *telemeter* is, of course, an angle-measuring instrument, and its essential parts consist of an astronomical telescope, movable round a horizontal and vertical axis, and of a graduated semi-circular limb, upon which any angle between 0° and 180° may be read by means of a vernier and microscope, which are fixed to the telescope. The telescope rests with its cylindrical pivots upon a support, which is fastened to a circular base-plate, and can revolve with the same horizontally round a conical pivot. This pivot rests again in an universal joint fastened to a tripod. The base-plate bears two electro-magnets, which may swing slightly round a horizontal axis, and which are armed with

two pole pieces. Below this is another horizontal circular base-plate of a little larger diameter, which rests on the same conical pivot and bears two standards, in which the graduated semi-circular limb rests with its horizontal axis in such a manner that both the axis of this limb and that of the telescope coincide in one line, which is at right-angles with the axis of the conical pivot. In order to arrest the telescope it bears upon its pivots two vertical and semi-circular arcs of iron, and the lower bottom plate on its circumference a ring of iron; both act as armatures to the electro-magnets, one pole of which is attracted upwards by the vertical arc, and the other downwards by the horizontal ring, whenever an electric current is allowed to pass through the instruments. It is thus possible to fix both instruments simultaneously by magnetic attraction of four poles in each. The telescope bears a catcher by which it communicates to the graduated limb its vertical oscillations, whilst it slides along the same when turned sideways. The angles read upon it are formed by the base-line between the centres of both telescopes and their respective optical axes. The *constructor* is composed of two graduated arcs, round the centres of which two long arms can turn, each being provided with a vernier, micrometer, and microscope near the circumference of the arcs. The distance between the centres of these arcs represents *en miniature* the base-line on deck of the vessel, and by fixing the movable arms with screws upon the angles which were observed with the telemeters, they construct the measured triangle, and the values for d_1 and d_2 may be read from their graduation, where they intersect each other. The foregoing observations will doubtless contribute to the general knowledge and just appreciation of M. Gurlt's ingenious telemetric instruments, which will be found highly useful and accurate for all requirements of hydrographical survey, naval gunnery, and coast defence.

MECHANICS, PHYSICS, AND CHEMISTRY.

Considerations on the Loss of the "London." By WILLIAM FAIRBAIRN, C.E., F.R.S., &c.

From the London Journal of Science, April, 1866.

The introduction of iron as a material in constructive art has been attended with great advantages. For the purposes of ship-building it has given greatly increased strength, and afforded facilities for obtaining new forms, which, aided by the power of steam, have ensured a rate of speed in vessels never before attained in naval history. It has, moreover, furnished the naval architect with a material of immense value as regards construction, and its careful distribution in the shape of ribs, frames, and the sheathing of vessels cannot be too highly appreciated. As compared with the best English oak, it exhibits four times its powers of resistance, and it has, in addition, the double advantage of being almost perfectly homogeneous and free from the defects of open joints, which, in the case of the planking of wooden vessels, require to be caulked. With all these advantages,

iron constructions are surrounded with many dangers when entrusted to the care and superintendence of incompetent persons; in such hands there invariably exists a want of proportion in the formation of iron vessels, which exhibit defective powers of resistance, and such other abnormal conditions as might prove destructive to the efficiency and ultimate security of the structure. It is, therefore, necessary that the naval architect or builder should be conversant with the properties of the material employed, whether considered separately or in combination; and, moreover, he should be satisfied that the vessel, when finished, is capable of permanently resisting the forces of tension and compression, and all the varied strains to which she is subjected when afloat.

In laying down the lines of a ship, all these conditions should be carefully and deliberately considered. It is also of importance to take into account the forms or lines of least resistance, such as a fine entrance at the bows, and an equally clear run at the stern, if high speed is the object to be attained. In such cases, these forms are highly advantageous for vessels navigating rivers and smooth water, but in those intended for long sea voyages, and having to contend with the waves of the Atlantic, or the rolling seas of the Cape, it is questionable whether or not some slight sacrifices should be made to speed, and some modification effected in the form of the bows and stern, in order to meet all the requirements of a safe and convenient vessel intended for the double purpose of carrying passengers and cargo.

I have been led to these particular considerations, not so much from the lamentable accident which overtook the *London*, as from the conviction, that the safety and success of a vessel does not depend so much on its speed as upon its sea-going properties and sound construction. If, for example, we take one of the present iron clippers—which make such quick voyages—with her sharp bows and fine proportions, I am of opinion that she is neither the safest nor the best description of vessel to contend with a heavy sea in foul weather. In the first place, she is a *diver*, which cuts into the sea and rises with difficulty from a *bath*, which covers her decks with water as she pitches from sea to sea. But these are not the only objections to vessels of this form, as repeated immersions of this kind are exceedingly uncomfortable to those on board, and cause the ship to lift some tons of water before her buoyancy is restored to meet the next and every other succeeding wave into which she plunges in a rolling sea. It is not my intention from these observations to depreciate the value of speed either in the Royal or Mercantile navy. On the contrary, I think it is the duty of every ship-builder to approximate as closely as possible to the lines of least resistance, which, in my opinion, ought to be carried to its utmost limits in smooth water, but in smooth water only.

In the construction of vessels of war, it was found expedient to rectify this want of displacement at the bows by projecting the submerged portion of the hull forward in the shape of a ram, not so much, however, for the purpose of attack, as to give buoyancy to the ship, and to enable her to rise more lively upon the sea. These defects of construction were observed in the iron-plated frigates *Warrior* and *Black*

Prince; the former vessel pitched and rolled heavily in the Bay of Biscay from similar causes, which from the first have been observable in all our high-speed ships. Viewing the subject in this light, it may not be out of place to suggest that all passenger and emigrant ships should be modified in their construction, so as to give increased displacement at the bows and stern, but more particularly at the bows, where they require buoyancy, having to encounter the force of a large body of water rushing over them and scouring the decks from stem to stern. Many of us remember the bluff, round bows of vessels of the last century, and how they rolled and pitched in a gale of wind. They were, however, short and compact, and although deficient in speed, they were, nevertheless, dry and excellent vessels at sea.

For several years I have endeavored to impress upon the minds of naval architects and others the necessity of increased strength on the upper decks of sea-going vessels, in order to balance the forces of tension and compression, and the double bottoms on the cellular principle of construction. The ultimate strength of a vessel is the resistance of its weakest part, and, this being the case, it is evident that it is of little or no value to have a strong double bottom if the deck is liable to be torn asunder by the alternate strains of a vessel pitching at sea. That these strains, often repeated, lead to fracture does not admit of doubt, and it has been proved by experiment that, under these circumstances, time is the only element in the endurance of the structure, and this varies according to the intensity with which the strains are produced. I offer these remarks from the conviction that heretofore the decks have been the weakest parts, and that several iron vessels have broken right in two from the constant working of alternate strains at midships along the line of the decks. I have, also, by way of illustration, compared an iron ship to a hollow girder, supported at each end and resting on the middle, for the exclusive purpose of showing the alternate changes to which she may be subjected if stranded or placed in the dangerous position of rising and falling on rocks in a heavy sea. Exceptions may be taken to these views, but they nevertheless exemplify what is necessary to be observed in the construction of a strong ship, and I may probably be excused the comparison, when the object in view is to effect security in the construction of our iron vessels.

I have been confirmed in my opinions on the forms and strain of vessels, from such facts as I was able to gather from the narrative of the loss of the ship *London*. From the accounts and the different statements of the witnesses examined before the Commissioners appointed by the Board of Trade, I was unable to discover any serious defect in the construction of the ship. On the contrary, I have reason to believe that both material and workmanship were perfectly sound, with the exception of the combings of the hatches, which it would appear were imperfectly secured. As respects the design, I have assumed that she inherited the extremely fine lines at the bow and stern already described, and to which I have directed attention, and additional weight is given to this opinion by the manner in which the vessel behaved at sea. Taking all the circumstances into account,

as also the statements of the different witnesses, with regard to the rigging and the state of the decks, I arrive at the conclusion that the ship did not founder from any serious defect of construction, excepting only the insecurity of the hatches, but from the hurried manner in which vessels are sent to sea, with their decks crowded with coal, hampers, and a variety of articles always dangerous and always objectionable in long and narrow vessels that are low in the water and liable to slip every succeeding sea. If these matters and the upper rigging had been properly cared for, there would have been no broken jib-boom to batter to pieces the combing of the hatchway, and instead of the *London* being entombed with all on board at the bottom of the Atlantic, she would, by this time, have been well advanced on her voyage to Australia.

For the Journal of the Franklin Institute.

Jets of Water.—*Experimental data arranged, and some practical hints,*
By S. W. ROBINSON, C. E.

The laws which govern the issuing of water from orifices of various forms depart so widely from mathematical theory, that it becomes necessary to adhere to the former in considering all questions relating to jets of water. These are only known from actual experiments, a large number of which have been made by numerous experimenters, mostly in Europe. The results of these experiments are certain numerical quantities, or co-efficients, each showing the deviation of the actual from the theoretical result for the particular case under consideration. In varying the conditions of the orifice, the fluctuation of the co-efficients is considerable, and is of great importance in all calculations pertaining to dynamic head, size and form of the orifice, quantity, the altitude and amplitude of the issuing jet.

It is sometimes desirable in practice to vary part of the conditions above-named, without changing others. This can only be accomplished by a thorough knowledge and judicious use of the experimental data, together with theoretical formulas. In this paper I propose to give some of the most important results of both theory and experiment upon jets of water, and show the use of both in a few examples.

The theoretic velocity with which water escapes from an aperture in a vessel, is the same as the acquired velocity of a body having fallen from a height equal to that of the water-level in the vessel above the orifice, which is—

$$v = \sqrt{2gh_0} \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

in which h is the height, and g the force of gravity at the place.

If s equals the section of the orifice, the quantity, or flow of volume, called the efflux, or discharge, will be the product of the sectional area by the velocity, or

$$Q = sv = \sqrt{2gh}h, \text{ or } = svt, \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

for the time t , s being the base and vt the length of the volume. This is the theoretic discharge.

The actual discharge is only secured by an application of the co-

efficient of discharge as established experimentally. Let m represent this co-efficient; then the actual discharge is—

$$Q^1 = m Q = m s v = m s \sqrt{2 g h_0} \quad . \quad . \quad (3.)$$

The co-efficient m varies slightly with the head and size of the orifice, and considerable with its form, and expresses the ratio of the actual to the theoretic discharge.

When the fluid is discharged through a thin plate, the vein undergoes a contraction or diminution of size, and a corresponding increase of velocity, the minimum section being at a distance from the orifice of about one-half times the mean diameter of the contracted vein, so-called, and the orifice. The ratio of the section of the contracted vein to the orifice is called the co-efficient of contraction; and the ratio of the velocity of the fluid particles at the contracted vein to the theoretical velocity is called the co-efficient of velocity. Let them be represented by n and u , respectively, and regarded as quantities belonging to the contracted vein alone.

Now, since the actual flow is the same at any section of the fluid vein, and equal the product of the section by the velocity, (2,) it follows that at the contracted vein—

$$u v . n s = \text{actual discharge} = m Q, \quad . \quad . \quad (4.)$$

in which $u v$ and $n s$ is the true velocity and section, respectively, of the contracted vein. But in equation (2), $Q = s v$, which substituted gives—

$$m = n u, \quad . \quad . \quad . \quad (5.)$$

that is, the co-efficient of discharge is always equal to the product of the co-efficients of contraction and velocity. At the contracted vein the velocity has been found to be very nearly the theoretic; consequently, the co-efficient of velocity is sensibly unity, and the co-efficient of discharge equal to the co-efficient of contraction. If a short cylindrical tube or ajutage, two or three times as long as its diameter, be applied to an orifice of the same diameter, the fluid will issue with but slight, if any, contraction; a case in which the co-efficient of discharge becomes very nearly equal to the co-efficient of velocity.

Among the most interesting experiments upon jets of water, and which give the greatest range in the values of m , n , and u , are those with conical tubes of various flare, the smaller base serving as the exit in one case, and the larger base in another. Further interest is added by prefixing an entrance mouth nearly of the form of the contracted vein.

I introduce here a table of co-efficients of discharge, velocity, and contraction, a table resulting from the labors of various experimenters, among whom may be mentioned Bossut, Mariotte, Castel, Venturi, Eytelwein, and others.

This table exhibits the co-efficients of discharge, velocity, and contraction, for ajutages differing in length from zero to 18.1 inches, and $50 \cdot d$; and in flare from 50° convergence to $10\frac{1}{4}^\circ$ divergence.

TABLE of co-efficients of discharge, velocity, and contraction.

Head in feet.	AJUTAGE.			CO-EFFICIENT OF—		
	Diameter, inches.	Length, inches.	Conver- gence.	Discharge.	Velocity.	Contraction.
				<i>m</i>	<i>u</i>	<i>n</i>
* 1 to 10	·61	1·57	50°	·842	·985	·854
"	·61	1·57	40°	·880	·979	·900
"	·79	1·97	30°	·900	·978	·920
"	·70	1·77	20°	·929	·970	·958
"	·61	1·57	16°	·939	·968	·970
"	·61	1·57	14°	·943	·964	·978
"	·79	1·97	13° 40'	·956	·964	·992
"	·61	1·57	13° 24'	·946	·962	·985
"	·61	1·57	12°	·944	·955	·988
"	·70	1·77	10°	·941	·950	·991
"	·61	1·57	8°	·935	·936	·999
"	·79	1·97	6°	·935	·932	1·000
"	·61	1·57	6°	·924	·924	1·000
"	·61	1·57	5°	·916	·915	1·001
"	·79	1·97	5°	·927	·925	1·002
"	·61	1·57	4°	·905	·904	1·002
"	·79	1·97	3°	·915	·909	1·006
"	·61	1·57	3°	·892	·890	1·002
"	·61	1·57	2°	·872	·870	1·002
"	·61	1·57	1° 30'	·863	·863	1·000
"	·61	1·57	0° 0'	·829	·830	·999
<i>h</i>	<i>d</i>	<i>d</i> †	"	·62	1·00	·62
<i>h</i>	<i>d</i>	2·5 <i>d</i>	"	·83	·83	1—
"	"	10· <i>d</i>	"	·78	·78	"
"	"	20· <i>d</i>	"	·74	·74	"
"	"	30· <i>d</i>	"	·70	·70	"
"	"	40· <i>d</i>	"	·66	·66	"
"	"	50· <i>d</i>	"	·62	·62	"
26·	·27	00·	"	·69	} Sensibly unity.	} Same as Dis- ch'ge.
1·	·39	"	"	·65		
2·	1·00	"	"	·62		
9·	2·00	"	"	·61		
12·	3·00	"	"	·61		
12·	7·00	"	"	·62	} Same as Disch'ge. At exit.	}
2·9	1·33	4·3	— 3° 30'	·93		
"	"	13·1	— 4° 38'	1·21		
"	"	18·1	— 4° 38'	1·34		
"	"	12·0	— 5° 6'	1·46		
"	"	6·9	— 5° 44'	1·02		
"	"	10·4	— 10° 16'	·91		

* Each result, as far as represented for the head of "1 to 10" ft., is a mean of five or six results from five or six heads, varying between one and ten feet.

† This tube was too short for the jet to fill; consequently, the co-efficients are same as for a thin wall or partition.

‡ The lengths here given are the lengths of the conical ajutages themselves. But a mouth-piece, nearly of the form of the contracted vein, was attached to each, forming an entrance mouth. This mouth-piece was found to increase the co-efficient of discharge in the ratio of 2 to 3, in the diverging or cylindrical tubes, less than one foot in length.

The co-efficients of discharge from the various forms of the orifice fluctuate from .61 or .62, for an orifice through a thin side, to 1.46 for the orifice provided with the mouth-piece and flaring ajutage.

The efflux resulting from the latter combination is more than double that from an aperture of equal diameter through a thin partition. Venturi concluded from his experiments upon diverging tubes and the mouth-piece, that a tube nine times as long as the diameter of the smaller base, and with a flare of $5^{\circ} 6'$, would give a discharge of nearly two and a half times that through a thin side, and nearly one and a half times as great as the theoretic. By means of the mouth-piece alone, Eytelwein raised the co-efficient of discharge from about .62 to .92, and with only the flaring tube recommended by Venturi, from about .62 to 1.18, and with both in combination, from about .62 to 1.55. According to these experiments, it will be safe to state, for a general approximation, that the mouth-piece increases the co-efficient of discharge in the ratio of 2 to 3, the flaring ajutage in the ratio of 3 to 5, and both combined in the ratio of 2 to 5.

Experiment also demonstrates that the application of the mouth-piece and flaring ajutage to conduit pipes of considerable lengths, say 300 times the diameter, does not appreciably affect the discharge.

The conical converging tubes, which serve in part as a mouth-piece, increase considerably the co-efficient of discharge as compared with that for a cylindrical tube, for all cases within the limits of the table, and have a maximum between 12° and 14° . The co-efficient of velocity increases with the convergence from .83 for the cylinder toward unity; but never, in any case, does the co-efficient of the velocity of projection pass that limit, whatever be the form of the orifice.* In the diverging tubes it exceeds the theoretic velocity at the orifice considered, but at the exit it falls much below. The jets, however, from these tubes cannot be relied upon where great regularity is desired, though the experimenters make no mention of irregularity for so great a divergence as $3\frac{1}{2}^{\circ}$.

The heights to which water will mount in jets nearly vertical, disregarding the resistance of the air, are proportional to the squares of the velocities of projection. In the formula $v^2 = 2g h_0$, h_0 is the head, and also the theoretic height of jet for the velocity v . But the true initial velocity, instead of being v , is vu ; consequently, the height of jet is—

$$h = \frac{v^2 u^2}{2g} = h_0 u^2 \quad . \quad . \quad . \quad . \quad (6.)$$

Substituting first $u = 1$, then $u = .65$, we get—

$$h_0 = \frac{v^2}{2g}, \text{ and } h = \frac{v^2 \cdot 42}{2g},$$

the difference of which is—

$$h_0 - h = \frac{v^2}{2g} - \frac{v^2}{2g} \cdot 42 = \frac{v^2}{2g} (1 - .42) = .58 h_0,$$

* Unless, from some cause, globules of air become mixed with the water, whose elasticity in passing the exit gives to the water an impetus by which it may rise ever higher than the fountain head.

a difference of more than one-half. But as we can hardly expect to make use of a co-efficient of velocity as low as $\cdot 65$, let us take it at $\cdot 82$ or $\cdot 83$, for a short cylindrical tube. Then we will have

$$h = \cdot 67 h_0;$$

that is, *the height of a jet from a short cylindrical tube is only about two-thirds that of a jet from an orifice in a thin side.*

These heights, however, are never fully realized, in consequence of the resistance of the air, together with the interference of the falling particles with the rising jet, when it is quite vertical. For this total loss of height, the experiments of Mariotte and Bossut lead to the empirical formula—

$$h^1 = h - 0\cdot 003 h^2 \quad . \quad . \quad . \quad (7).$$

In very small jets, the co-efficient of h^2 is sometimes taken as high as $0\cdot 01$. The greatest altitude possible in any case results from inclining the jet slightly from the vertical, to avoid the interruption caused by the descending drops.

When water spouts from an orifice in any other direction than vertical, its path described will be very nearly the arc of a parabola. The air causes a slight but almost imperceptible deviation therefrom. Experiments show that a sufficiently close approximation for practical purposes is secured by using about $\cdot 98$ of the actual velocity of projection, and proceeding with the following formulas:

The equation of the curve described, regarded as a parabola taking the origin of co-ordinates at the orifice, is—

$$h = x \tan. \alpha - \frac{g x^2}{2 v^2 u^2 \cos.^2 \alpha} = x \tan. \alpha - \frac{x^2}{4 u^2 h_0 \cos.^2 \alpha} \quad . \quad (8),$$

in which h is the vertical ordinate, x the abscissa, and α the angle of elevation, or projection, reckoned from the horizon.

The altitude, or greatest elevation of the jet above the orifice, is given by the formula—

$$h_1 = \frac{v^2 u^2}{2g} \sin.^2 \alpha = h_0 u^2 \sin.^2 \alpha \quad . \quad . \quad (9).$$

The amplitude, or distance to the intersection of the jet with the horizon of the orifice, is—

$$A = \frac{v^2 u^2}{g} \sin. 2 \alpha = 2 h_0 u^2 \sin. 2 \alpha \quad . \quad . \quad (10).$$

The angle of projection, in terms of the altitude and amplitude, is—

$$\tan. \alpha = \frac{4h_1}{A} \quad . \quad . \quad . \quad . \quad (11).$$

Formulas (9) and (10) follow directly from (8) by making the necessary suppositions, and (11) is obtained from (9) and (10) by eliminating h_0 .

In the balance of the article I propose to illustrate, in some degree, the application and practical utility of the preceding table and formulas, by a few examples and comments.

It is sometimes desirable to so dispose a series of orifices at the ex-

tremity of the same pipe-main, as to give a compound or sheaf jet, with a variegated combination of altitudes and amplitudes.

EXAMPLE 1.—Suppose we have an effective head of $h_0 = 12$ feet, to determine the height of a vertical jet issuing from an orifice in a thin wall, and also from a short tube.

First, for an orifice in a thin wall: $u = \text{unity}$, and from (6) or (9), since $\alpha = 90^\circ$, we have $h = h_0 u^2 = h_0 = 12$ feet, u being unity. Applying the correction of (7) for vertical jets, we get $h^1 = 12 - 0.003 \times 12^2 = 11.6$ feet, for the correct height.

Secondly, for the short tube: $u = .83$, which, in (6), gives $h = h_0 \cdot 83^2 = 12 \times .69 = 8.3$ feet, which becomes 8.1 feet, after correcting for resistance of air and interference of particles by formula (7).

EXAMPLE 2.—Given the altitude, $h_1 = 10$ feet, and amplitude, α : first = 15 feet, second = 25 feet. Required the angle and velocity of projection in each case, the correction for the resistance of the air, and the form of each orifice to give the required jets from a common head.

First, $\tan. \alpha = \frac{4 h_1}{A} = \frac{40}{15} = 2.666 +$; hence $\alpha = 69^\circ 26'$. From

(9) we obtain velocity $vu = \frac{\sqrt{2g h_1}}{\sin. \alpha} = 27.10$, by substitution and re-

duction. But, from a consideration of the resistance of the air, we will have, according to what has been said, $vu = .98 v' u$, or $v' u = \frac{vu}{.98} = \frac{27.10}{.98} = 27.66$, for the required velocity of projection.

Second, $\tan. \alpha = \frac{4 h_1}{A} = \frac{40}{25} = 1.60$; hence $\alpha = 58^\circ 00'$. Also, simi-

larly, as before, the velocity $v' u' = 29.91$, and $v'' u' = 30.52$.—Now, since v' , v'' are the theoretical velocities required, and assumed to be due to a common head, we have $v' = v''$, and may be eliminated; whence $u 30.52 = u' 27.66$, or $u = u' .906$; that is, the ratio of the co-efficients of velocity must be .906. If, then, we adopt the cylindrical tube for one orifice, the other will have a convergence of about 5° . Similarly, if for one orifice we adopt a tube of 50° convergence, the other must have a convergence of about 3° .

Substituting the values of u , u' for the first case, $v = 33.32$ feet, and $h_0 = 17.26$ feet, and for the latter $v = 30.99$ feet, and $h_0 = 14.93$ feet.

EXAMPLE 3.—Let it be required to construct a sheaf jet of nine orifices, three nearly vertical, and six much more inclined, for which we have a common head of 15 feet. The three central jets are each to have an altitude of 14 feet, and amplitude of 1 foot. The six remaining ones each to have an altitude of 9 feet, and amplitude of 9 feet. Two forms of orifices are necessary, of different co-efficients of velocity. Required the two forms and their angles of inclination. The following quantities appear in the computation:

	For one of the three jets.	For one of the six jets.
Altitude = $h =$	14.	9.
Amplitude = $\Delta =$	1.	9.
Tangent $\alpha = \frac{4h}{\Delta} =$	56.00	4.00
Angle of projection = $\alpha =$. .	88° 58'	75° 58'
Theoretic velocity = $v =$. . .	31.07	31.07
Velocity of projection for non-interference of air = $v u =$. .	30.66	25.81
Velocity of projection for resistance of air = $\cdot 98 v u =$. . .	30.05	24.80
Co-efficient of velocity required = $u =$	.987	.815

The orifices having these co-efficients of velocity are, for the first, the conical tube of about 50° convergence; and, for the second, the cylindrical tube about 4.7 as long as its diameter. These tubes should be set with the inclination of their axes corresponding to the angles of projection, and at such a distance from each other as to allow the free ingress of the water.

Suppose the discharge of the individual jets to be equal, and the aggregate discharge of the sheaf jet to be about 7. cubic feet per minute. Then—

	For one of the three jets.	For one of the six jets.
Discharge per minute, ... {	.768 cu. ft. for one orifice.	.768 cu. ft. for one orifice.
Discharge per second, ...	.0128 cu. ft.	.0128 cu. ft.
Velocity, (theoretical,)	31.07	31.07
Co-efficient of discharge for equal orifices,	.841	.815
Section of orifice, ...	.00049 feet.	.00051 feet.
Diameter of orifice, ...	.300 inch.	.305 inch.

Service-pipes for fire-engines are usually from two and a half to four and a half feet in length, of the same inner diameter as the hose coupling, say two and a half inches at one end, and about one and a half or two inches at the other, where the ajutage or nozzle is attached. The nozzle is usually from five to eight inches in length, with the inner surface conical, of five to ten degrees convergence, terminated frequently with a cylindrical continuation, which is probably no improvement whatever. Referring to the table, we observe there is practically no contraction of the vein for so great a convergence as 10° or 12°; hence, for a less convergence than this, the cylindrical extension simply interferes with the free egress of the water. Experiment shows that the more convergent the ajutage, the more smooth and beautiful will be the stream. The table exhibits a greater discharge, at a higher velocity, for a convergence of about 14°, and a

still greater velocity, but with less discharge, for 25° convergence. But the greatest velocity of all is indicated for simply a perforated disk, in place of the service-pipe, upon the end of the hose. The heights being proportional to the square of the velocities, we will have

$H(5^\circ)$ to $H(14^\circ)$ to $H(25^\circ)$ to $H(\text{disk})$ as $\cdot 85$ to $\cdot 93$ to $\cdot 95$ to $1\cdot 00$,
and the discharge as $\cdot 92$ to $\cdot 95$ to $\cdot 92$ to $\cdot 64$.

These figures show that the greatest aggregate result, of both height and velocity, in trials of fire-engines, is secured with a nozzle of about 14° convergence on the inside surface, a greater convergence than is common. These conditions may vary slightly for the great head or pressure brought to bear upon the orifice in such trials. Notwithstanding the above figures show the greatest velocity and height for the perforated discoidal cap upon the hose extremity, still, remembering that the section of the stream in the latter case is only $\cdot 65$, that for the tubes, on account of contraction, and the retardation being greater for small jets, other conditions being equal, it is probable that the greater velocity will no more than compensate for such loss.*

It is probably safe to infer from the preceding that the most favorable form of the nozzle, for the greatest aggregate result in trials of fire-engines, follows from the use of a nozzle of about 14° convergence.

On the Properties of Parkesine and its Application to the Arts and Manufactures. By ALEX. PARKES, Esq., of Birmingham.

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Continued from page 271.

In reply to inquiries by Admiral Sir Edward Belcher, it was stated by Mr. Parkes that the solvent employed in this process was naphtha—either vegetable or mineral; that the present price of parkesine ranged from 1s. per pound upwards, according to quality; that its specific gravity was about equal to that of gutta percha; that no experiments had yet been made with regard to the resistance of this material to cannon.

Sir Edward Belcher thought it was likely to be very valuable for filling in of the intervals between the plates and the backing in iron ships of war instead of teak. He thought it would afford greater resistance to shot, and there would be no splinters. He wished to know whether it was inflammable.

Mr. Parkes replied that it could be made almost unflammable; and, moreover, when used in contact with iron, it had no tendency to produce oxidation. With proper machinery a ton weight of the material would be produced in half an hour. As a varnish, (a specimen of which was exhibited,) it could readily be applied to the bottoms of iron ships to prevent corrosion from sea-water. Experiments were

* In one experiment, made in accordance with my suggestion, by F. B. Gilman of Springfield, Vermont, using a forcing pump driven by water power, the stream reached a horizontal distance of 100 feet for the ordinary nozzle. On application of the perforated discoidal cap, all other conditions remaining the same, the jet reached a horizontal distance of 110 feet.

being carried on with regard to its imperviousness to the attacks of marine insects, but the results had not yet been ascertained.

Mr. Owen Rowland said: Having been for some time engaged in making experiments upon this material, with a view to its application to telegraphic purposes, he thought it would be interesting to hear the results of those experiments. He had watched with great interest the progress of this invention for the last three years, and, like all great inventions, it had had a great deal to contend against, because it was very likely to displace many articles which were now very much in popular favor and use. He had kept several specimens of various materials (this one amongst the number) exposed to atmospheric influences, under different conditions, during the time he was engaged, on the part of the Board of Trade, in testing different insulating substances. He found that atmospheric exposure had not the least effect upon this material. It was not rendered less elastic, and its toughness was not diminished, nor was their the least approximation to decomposition. In that respect, he believed it would be most valuable from its non-oxidizing properties. In regard to its application to telegraphic purposes, he was sure they would all say they could not but wish to see a material introduced which would extend the great advantages which the telegraph was calculated to confer upon society. There was room for many materials for this purpose, and he was sure telegraphy had suffered immensely from the doubts existing in men's minds as to the sufficiency of the insulators now generally employed. The battle of the insulators in telegraphy had rivaled that of the gauges in the earlier days of railroads. For a considerable time past the efforts made to furnish a new insulating material had been very great; from day to day combinations were produced, which he had submitted to the test of the particular form of electrometer he had before him, (Peltier's,) which was unerring. The results of his tests of the substance now under consideration led him to think that in this material they would eventually have an excellent, cheap, and efficient insulator. On the paper placed on the board at the back of the chair he had arranged specimens of the material of different qualities, and he had tested the insulating powers of each specimen. The instrument employed in the testing was charged to a tension of 50, representing 512 cells of Daniell's battery. He placed this instrument in contact with the insulating material, and then watched the fall of the needle. If the needle fell so much in a minute with one article and fell more with another, then the former was the superior insulator. The results of these experiments were given in the table at the end of the paper. He did not agree with the plan of testing cables which had hitherto been pursued; he believed it had not been half severe enough. He had tested some hundreds of miles of the Atlantic cable, and he considered the test was not stringent enough. Sufficient attention had not been paid to the temperature and dryness of the atmosphere. In making his (Mr. Rowland's) experiments, the room in which the testing was to be carried on was kept at a temperature of 61° to 65°, and the hygrometric state of the atmosphere carefully

ascertained. The first attempt with material No. 9 (in the table) showed a leakage; that was, the needle of the instrument fell down 11.5° in 25 seconds; with No. 3 it fell down the same amount in 180 seconds; with No. 2 in 510 seconds; with No. 1 in 1080 seconds; with No. 8 in 509 seconds, and this was an excellent insulator; with No. 10 in 2046 seconds, and so on with the rest, while ebonite took 1050 seconds. Ebonite, which had been very much used, had been generally regarded as a very excellent article for these purposes, but he considered it had been surpassed by this invention. No proper machinery had as yet been constructed for the production of this article as it was intended to be ultimately manufactured. It required the utmost cleanliness and purity in its manipulation when intended for insulating purposes. Those were important considerations in all electrical matters, and, having witnessed the manufacture of several telegraphic cables, he was pleased to see that this material, even though as yet imperfectly manufactured, promised so well as an insulator. He remembered that in the first manufacture of gutta percha considerable impurities existed, and in many cases a really good insulating material had been condemned entirely through the foreign matters which it contained. He had a very strong opinion of the durability of this material. He saw no change in it, in whatever conditions he had placed it. He had boiled it in water, had exposed it to a hot sun, and had tested it in conditions to which it would never be exposed when used for electrical purposes, and he found little or no effect produced upon it. What was required for the perfecting of the invention was machinery into which no impurities could enter. He was very glad to find this invention brought before the Society of Arts, as had been done in the case of some of the greatest inventions ever produced. Twenty-one years ago he assisted Mr. Fothergill Cooke in exhibiting an electric telegraph in this room, which, on its first introduction to the world, had a great deal to contend against. He confidently expected to see this new material taking its place in the great and important work of extending electric telegraphy.

Mr. Wilson inquired the means by which this material could be joined together?

Mr. Parkes replied it was joined by means of its own solvent, and became a homogeneous mass.

Mr. Benjamin Fothergill asked whether, in the event of this material being employed on iron for rollers, there was any danger of its becoming disunited from the iron?

Mr. Parkes replied that, from its elastic and cohesive property and contractile force, he could not imagine that it would separate from the iron.

Mr. Taylor remarked that, as the inductive capacity of materials employed in telegraphy was a point of great importance, he should be glad to hear whether this material exhibited any advantages in that respect.

Mr. Rowland replied that the figures he had given might be said to represent the inductive capacity of the material. He believed it to be about equal to india rubber in that respect.

Dr. Bachhoffner said the variety of applications to which this material seemed to be adapted rendered it one of considerable interest and importance. As to its applicability to telegraphic purposes, practical trial alone could decide the question. The conclusions arrived at by Mr. Rowland, as the result of his experiments, were entitled to weight, but he believed it was a question whether that perfect insulation spoken of was the best condition for an electrical cable. However that might be, there could be no doubt that in this invention a very important addition had been made to our manufacturing resources, and he hoped his friend in the chair would not object to the inventor enjoying the benefits of a patent for it. It was always the privilege of an Englishman to grumble, and he claimed that privilege on the present occasion, inasmuch as having seen the announcement that "parkesine" was to be the subject of discussion this evening, he consulted every book in his possession in the endeavor to ascertain what parkesine was, but he failed in obtaining the information. He begged to raise his protest against inventions of this kind being called after the name of the inventor; for though, doubtless, this name would be handed down in connexion with the material, yet, as there were a great number of Parkes, many of that name might unjustly arrogate to themselves the merit of this invention. It was, however, often the case that great discoveries were associated with the patronymic of the inventor or discoverer, as in the cases of Galvani and Volta in connexion with galvanic or voltaic electricity, and MacAdam, the inventor of the modern system of roads; but he thought, from the multiplicity of purposes to which this material was adopted, it would be well to give it a name which would convey a better idea of what it was than could be gained by the public generally under its present title.

The Chairman said it was now his pleasing duty to ask the meeting to thank Mr. Parkes for his paper, practically illustrated as it had been by the observations of Mr. Rowland. He should, perhaps, have objected somewhat to this paper, in its present form, being read, had he not known that it would be supported, as it had been, as a matter of principle, by Mr. Rowland, whose views were entitled to so much weight. So far as his own individual opinion went, he thought it desirable that papers read before a Society like this should not have for their object merely the description of some particular invention, but should be more general in their character. No one, however, could question the importance of a discovery which introduced a material likely to be of great value in the arts and manufactures of the country, and the want of which was becoming more and more felt. We were exhausting the supplies of india rubber and gutta percha, the demand for which was unlimited, but the supply not so. In the case of gutta percha, the tree was destroyed in taking the produce of it, and we had to wait till other trees grew for future supply; and, with regard to india rubber, the plants only produced a limited quantity each year. This new commodity, however, was produced from materials of which there was an unlimited supply, and as such its applica-

tion to the purposes of electric telegraphy would be a matter of the highest interest and importance. Here he would make an observation in reply to the joke on the subject of patents, made by his friend, Dr. Bachhoffner, who was an advocate of one principle, while he (the chairman) supported the contrary view. That gentleman had taken the opportunity of assuming that he (the chairman) could not object to the inventor of this material having patented it, and deriving benefit from that patent. Certainly he did not object to his being benefited by the result of his labors through the means of a patent; for so long as the patent laws existed they were open to all; and he himself, though he thought, on the whole, they were injurious to the country, would not hesitate to benefit by them so long as these laws remained in force. But the argument of Dr. Bachhoffner was in reality in his favor. He objected to the name of parkesine being applied to the material, because there might be many "Parkes." That was, in fact, the great objection to the whole principle of the patent laws. In this country there was scarcely a process or invention, or a new application of science to the arts, that hundreds of persons were not engaged on at the same moment of time. It was only a question which would be first to go to the patent office and secure the benefits of that which was occupying the time of a hundred other persons, whose results would have appeared in due course if a patent had not been secured by one, who thus impeded the labors of the others. The result was to give a monopoly to one person in a matter which ought to be shared in by many. As the law now stood, it was not the man whose ability and scientific knowledge brought about a great invention who got the benefit of it, but it was the most active and energetic man of business, who, simply by being the first to secure the patent, derived all the advantages. It was clear, if they looked at the specimens on the table, that this material was applicable to a vast variety of uses, from a shoe-sole to articles of ornamental art, and he was sure the meeting would unanimously agree that Mr. Parkes was entitled to the thanks of the Society for the very interesting subject he had brought before them this evening.

The vote of thanks was then passed and duly acknowledged.

Scientific Aërostation.

From the London *Mechanics' Magazine*, July, 1865.

The art of traversing the air by means of balloons is of comparatively recent date. The germ of the invention of the balloon is to be found in the discovery by Cavendish, in 1766, of the remarkable lightness of hydrogen gas. It first occurred to Professor Black, of Edinburgh, that a light envelope filled with this gas would rise of itself, and he procured a thin animal membrane to make an experiment, which, however, he never carried out. Cavallo, in 1772, made the first practical attempt at ballooning by inflating swine's bladders with the gas. But he failed; and it was left for the Brothers Montgolfier to perfect the idea and to invent the balloon. The first attempt to

render the balloon of practical utility appears to have been made in 1794, during the wars of the Revolution, when an aërostatic institution was formed at Mendon, near Paris, for training a corps of "aërosters" in order to observe the enemy by means of balloons. At the battle of Fleurus, near Charleroi, fought against the Austrians, a balloon, under the management of the corps, was present, and according to the testimony of Jourdan, the General in command, it rendered signal service. More recently, if report be correct, a similar method was adopted during the seven weeks' campaign in Italy, in 1859. Balloons have also been enlisted in behalf of science by a past generation as well as in recent times. On the 18th July, 1803, Robertson and Lhoest made the first ascent for avowedly scientific objects at Hamburg. These observers testified to the diminution of terrestrial magnetism, and the general feebleness of electrical and galvanic phenomena in the rarer portions of the atmosphere. These results were considered of such importance by the French Institute, that they arranged for another ascent. The management of the balloon and of the physical experiments was entrusted to MM. Biot and Gay-Lussac, who started on the 20th August, 1804. This experiment proved unsuccessful, and a second was undertaken shortly afterwards by Gay-Lussac alone, when he rose to a height of 23,000 feet. After a series of experiments, the French *savans* were unable to confirm the results given by Robertson and Lhoest; they could not find any perceptible diminution in the intensity of electrical phenomena in the upper air. Since that time until the present, very few scientific aërial voyages have been undertaken, the principal being that of Humboldt in America, those made by Mr. Rush, accompanied by Mr. Green as steersman, on behalf of the British Association during 1847-49, and those by MM. Barral and Bixio at Paris, in June and July, 1850. Although, from accidents, the two last-named ascents were of short duration, yet some interesting results accrued therefrom. Amongst other things, the aëronauts noticed that they passed through a cloud of icicles which appeared to them to sustain themselves in the air contrary to the laws of gravity. Upon their horizontal surfaces they saw beneath them an exact image of the sun, formed by the reflection of the luminous rays on the crystals of ice floating about in a foggy atmosphere. It was further observed that the temperature of the cloud was as low as minus 40° , a far greater degree of cold than has been experienced in later ascents. No facts of importance appear to have been established by any other ascents than the last noticed, and the contributions of balloons to positive science might be set down to almost nothing, until very recently, when the revelations made by Mr. Glaisher have given a fresh impetus to and awakened a new interest in aëronautics.

More than two years since, Mr. Glaisher communicated to the Royal Institution the results of eight ascents he had made for the purpose of scientific research in the higher regions of the atmosphere. Since that time he has made seventeen additional aërial voyages and has added many interesting and important facts to the annals of physical

science. In making a balloon ascent, a novel sensation is at first experienced; at great elevations, the air is exceedingly cold and dry, and should the aerial traveler rise to an elevation too great for his power of endurance he enters upon a painless death, which is only comparable to that of a mountain traveler who, benumbed and insensible to suffering, yields to the overpowering lethargy. As in the latter, so in the former case, the only means of safety lie in moral energy. The subjects of research by means of balloons may be classed under six heads. First. To determine the rate of decrease of temperature with increase of elevation, and to ascertain whether the results obtained by observations on mountain sides, viz: a lowering of the temperature of 1° for every increase of elevation of 300 feet, are correct or not. Second. To determine the distribution of the water in the invisible shape of vapor in the air below the clouds, in the clouds themselves, and above them, at different elevations. Third. To compare the results, as found by different instruments, together: 1. The temperature of the dew-point, as found by dry and wet thermometers, (free;) dry and wet thermometers, (aspirated, or air made to pass rapidly;) Daniell's dew-point; Regnault's dew-point, (blowing;) Regnault's dew-point, (air made to pass rapidly.) 2. To compare the readings of mercurial and aneroid barometers, &c. Fourth. Solar radiation, by taking readings of the blackened bulb thermometer fully exposed to the sun, with simultaneous observations of the dry bulb thermometer, and also of observations of Herschel's actinometer. In the fifth place, to determine whether the solar spectrum, when viewed from the earth and far above it, exhibits any difference; whether there are a greater or less number of dark lines crossing it, particularly at the approach of sunset. Lastly, to determine whether the horizontal intensity of the earth's magnetism is less or greater with elevation. Upon most of these points a large amount of information is afforded by Mr. Glaisher's experiments, the results of which he has recently placed before the Royal Institution in a lengthy and exhaustive communication.

In determining the first point, as to decrease of temperature, it was found that the state of the sky exercised a great influence, which rendered two sets of experiments necessary—one set with cloudy, and the other with clear skies. The results of a series of experiments show the decline of the temperature of the air with elevation, when the sky was cloudy, to be 4.5° at the height of 1000 feet, or 1° in 223 feet. From 1000 to 2000 feet the decline was 3.6° , or 1° in 278 feet; from 2000 to 3000 feet 3.7° , or 1° in 271 feet; from 3000 to 4000 feet 3.4° , or 1° in 295 feet; from 4000 to 5000 feet 3.3° , or 1° in 333 feet. From 9000 to 10,000 feet the decline was 2.2° , or 1° in 455 feet; from 15,000 to 16,000 feet 2.1° , or 1° in 477 feet; and from 22,000 to 23,000 feet 0.8° , or 1° in 1250 feet. Up to 5000 feet, the number of experiments upon which each result is based varies from 13 to 22. From 7000 to 16,000 feet the results are based upon four experiments, which were made on the 26th of June and the 29th of September, 1863, on which days the balloon was frequently enveloped in fog and clouds

to the height of three or four miles. The results above 16,000 feet were obtained on the former of the above days only, during the ascent and descent, the sky being covered with clouds when the balloon was between four and five miles high. The decline of temperature with elevation, when the sky was clear, was found to be 6.2° at 1000 feet, or 1° in 162 feet. From 1000 to 2000 feet 4.7° , or 1° in 213 feet; from 2000 to 3000 feet 3.8° , or 1° in 264 feet; 3000 to 4000 feet 3.3° , or 1° in 304 feet; 4000 to 5000 feet 2.9° , or 1° in 345 feet; from 9000 to 10,000 feet 2.4° , or 1° in 417 feet; from 14,000 to 15,000 feet 1.7° , or 1° in 588 feet; from 19,000 to 20,000 feet 1.3° , or 1° in 771 feet; and from 28,000 to 29,000 feet, the decline was 0.8° , or 1° in 1250 feet. Up to the height of 22,000 feet, the number of experiments varies from 7 to 17, and there can be but little doubt that the numbers showing the decrease of temperature are very nearly true, and approximate closely to the general law. Above 24,000 feet, the number of experiments is comparatively few, but the results accord with those obtained from experiments at lower elevations. Under a clear sky a decline of 1° in temperature takes place within 100 feet of the earth, and at heights exceeding 25,000 feet 1000 feet of vertical height have to be passed through for a decline of 1° of temperature. By adding together successively the decline of temperature for each 1000 feet, the whole decrease of temperature from the earth to the different elevations is found. The results with a cloudy sky are as follows: From 0 to 1000 feet the decrease was 4.5° , or 1° on the average of 223 feet; from 0 to 2000 feet 8.1° , or 1° on the average of 247 feet; from 0 to 3000 feet 11.8° , or 1° on 255 feet; from 0 to 4000 feet 15.2° , or 1° on 263 feet; from 0 to 5000 feet 18.5° , or 1° on 271 feet; from 0 to 10,000 feet 31.0° , or 1° on 321 feet; from 0 to 15,000 feet 42.1° , or 1° on 356 feet; and from 0 to 23,000 feet 51.7° , or 1° on the average of 445 feet. These results, showing the whole decrease of temperature of the air from the earth up to 23,000 feet, differ very considerably from those with a clear sky. In the latter case, the numbers showing the average increase of height for a decline of 1° of temperature from the ground, are all smaller than those with a cloudy sky at the same elevation. The experiments show that a change takes place in the first 1000 feet of 1° on an average in 162 feet, increasing to about 300 feet at 10,000 feet. In 1862, this space of 300 feet was at 14,000 feet high; and in 1863, at 12,000 feet; therefore the change of temperature has been less in 1863 than in 1862, and less in 1864 than in 1863. The experiments have all been taken at different times in the year. Without exception, the fall of 1° has always taken place in the smallest space when near the earth.

The observations upon the second head, for determining the degrees of humidity of the air, when treated in a similar manner to the preceding, show the law of moisture to be, with a cloudy sky, a slight increase from the height of 3000 feet. After this, a slight decrease occurs to 6000 feet, the degree of humidity being, at this elevation, nearly of the same value as on the ground. From 6000 to 7000 feet there is a large decrease, and then an almost uniform decrease to

11,000 feet. It increases again from 12,000 to 16,000 feet, and then decreases. With a clear sky, the law of moisture is shown to be a slight increase to 1000 feet, a considerable increase between 1000 and 2000 feet, a nearly constant degree of humidity from 2000 to 5000 feet, and subsequently a gradual decrease to 12,000 feet. The numbers at greater heights become rather irregular. Whether the sky was cloudy or clear, Mr. Glaisher invariably found that, at extreme elevations, the air became very dry, but, as far as his experiments went, never quite free from water. The results for temperature were laid down on a diagram at the end of 1863, and the resulting curve was a hyperbola. Continuing this curve upward and reading out the decrease of elevation, the result would be that, at the height of 50,000 feet, the decline of temperature from the earth would be 83° . At 100,000 feet or 19 miles, the decline would be 97° , at twice that distance 106° , at 100 miles $112\frac{3}{4}^{\circ}$, and at 200 miles $116\frac{1}{2}^{\circ}$. This shows that large changes occur near the earth, amounting to 24° in the first mile, and becoming less and less the further removed, until the change from 100 to 200 miles is less than 3° . The foregoing results were deduced chiefly from experiments made in the summer and during the day. In order, therefore, to ascertain whether that law held good at all times of the year, experiments were made at other seasons. From these it was found that the season and the time of the day influenced the results very materially, the experiments made during the winter months differing very much from the general laws. The particulars of each ascent are such that they cannot all be combined or all used in deducing general laws. Recent ascents, made under similar conditions to those from which the laws of decrease of temperature were found, when combined do not affect the previous results, but ascents made in winter differ very greatly, and this deviation is of great importance. Mr. Glaisher met a strong current of air from the south-west nearly one mile in depth, which passed over this country on the 12th of January, and continued for many days, and which must have exercised great influence. This is the first instance of a stream of air of higher temperature than on the earth having been met with. The observation of this south-west current is highly important, as bearing upon the very high mean temperatures experienced during winter, the probability being that the variations of our winters are due to its fluctuations. The general result of the differences in the law of decrease of temperature, lead to the conclusion that the theoretical law of refraction now used must be abandoned, and that every observatory will have to determine its own laws independently.

With regard to solar radiation, the blackened bulb thermometer, and Herschel's actinometer observations, Mr. Glaisher found on the 31st of August last, that, at the heights of 7000 and 8000 feet, the blackened bulb thermometer, exposed to the full influence of the sun, read only 3° higher than the shaded thermometer. On the 29th of September, at the height of 14,000 feet, the excess of reading of the blackened bulb was $2\frac{1}{2}^{\circ}$ only under a bright sun; the increase of readings of the actinometer was from 3 to 5 divisions only. At 13,000 feet

the excess of the blackened bulb readings increased to 4° and 5° , and the increase in one minute of the actinometer readings was 7 to 8 divisions. At the height of 3000 and 4000 feet the influence of the sun increased, raising the blackened bulb to 7° and 8° , in excess of the shaded thermometer; the scale readings of the actinometer increased to 20 and 25 divisions in one minute, and on reaching the ground the increase in the same time was from 45 to 50 divisions. On some occasions the readings of the shaded and exposed thermometers have been found to correspond, whilst in others, the blackened bulb thermometer has read lower than the shaded thermometer. Hence, it appears that the heat rays in their passage from the sun pass the small bulb of a thermometer, communicating little or no heat to it. Herschel's actinometer invariably gave similar results. The inference is, that the heat rays from the sun pass through space without loss, and become effective in proportion to the density of the atmosphere or the amount of water present through which they pass. Another point established by practical observation is, that the velocity of the air at the earth's surface is much less than at high elevations. On one occasion the balloon traversed a distance of 95 miles in 2 hours and 47 seconds, the horizontal movement of the air on the earth in the locality traversed being registered as 33 miles during the above time. On another occasion a trip of 35 miles was accomplished by the balloon in the same time that the air traveled 8 miles on the earth. Still greater was the difference in another instance, when the distance traversed by the balloon was 70 miles, and the distance traversed by the air below was recorded as 6 miles only. From a series of experiments the conclusion is, that at high elevations a considerable increase occurs in the velocity of the air, which increase, however, is not constant in relation to the velocity at the surface of the earth. Observations also determine the existence of widely different currents in the atmosphere, the wind, in some cases, having been found to change from east to west in the course of a voyage. Respecting the comparison of the temperature of the dew-point by different instruments, it is found that in all the experiments there is no certain difference in the determination of the dew-point by Daniell's and Regnault's hygrometers. This temperature, determined by the use of the dry and wet bulb thermometers, appears to be very closely approximate to the results obtained by either of those instruments. The balloon, as we find it, certainly claims a position among the most important of human inventions, and will continue do so if even it remains an isolated power. But this is not its probable fate; it has already done for science that which no other power has accomplished, and there are around us growing signs of its further utilization.

Non-explosive Gunpowder.

From the London Mechanics' Magazine, July, 1865.

We recently noticed the discovery, by Mr. Gale, an electrician of Plymouth, of a method whereby gunpowder may be rendered explosive

or non-explosive at will. Some interesting experiments, illustrative of this discovery, were made last Saturday in a large tent at the Wimbledon rifle gathering. The process, which is very simple, consists of mixing two parts of dark impalpable powder with the gunpowder to be rendered non-explosive, thoroughly incorporating the two, and the operation is complete. The mixture at first sight, differs little in appearance from the impalpable powder itself, except that on close inspection, the shape of some of the grains of gunpowder can be detected. Each grain of gunpowder is isolated by an envelope of the impalpable or non-explosive powder, and, as a consequence, when fire is applied to the mixture, the gunpowder will only explode grain by grain as the fire reaches it. A quick-match was thrust to the bottom of a bowl of the mixture and set on fire. After the match had burnt beneath the surface a few grains of gunpowder were exploded, one by one, until the match was consumed. To render the powder again explosive, all that is necessary is to place the mixture in a fine sieve and sift away the non-explosive powder. The separation apparently can be perfectly effected. No particles of the non-explosive powder adhere to the gunpowder, which burns after the operation as rapidly and with as little residuum as before. The inventor states that in five minutes a barrel of gunpowder can be rendered non-explosive, and in another five minutes be restored to its original combustible condition. A shell might burst in a store of this mixture in bulk without any explosion except that of the shell itself. Gunpowder so treated may be stowed with perfect safety in any common shed or warehouse, and stowed also in bulk. Another reason why great care requires to be exercised in storing gunpowder is, that it absorbs moisture from the air very readily, and if not kept thoroughly dry soon becomes unfit for use. The non-explosive powder is stated by Mr. Gale to be in this respect totally different from gunpowder; that is to say, it does not absorb moisture from the atmosphere, and, as a consequence, it protects the gunpowder with which it is mixed. The inventor burnt some gunpowder which he stated had been kept for months in the mixed form under an open shed. In spite of this exposure, the grains of gunpowder was as hard, and the combustion so rapid and complete, as if they had just come from the corning mill. It is true that the bulk and weight of the mixture are three times as great as that of the gunpowder itself, but it can be stored in bulk in very little, if any, greater space than is required by gunpowder in barrels; and, as regards the question of carriage, there is no doubt that, for commercial purposes, three tons of the non-explosive compound would not cost so much as one ton of gunpowder. Mr. Gale has been ordered by the Secretary of State for War to attend immediately before the Ordnance Select Committee, and submit his discovery to their investigation.

A New Explosive Substance.

From the London Mechanics' Magazine, August, 1865.

Glycerine, as we all know, is the sweet principle of oil, and is extensively used for purposes of the toilet, but it has now received an

application of rather an unexpected nature. *Galignani* states that in 1847, a pupil of M. Pelouze's, M. Sobrero, discovered that glycerine, when treated with nitric acid, was converted into a highly explosive substance, which he called nitro-glycerine. It is oily, heavier than water, soluble in alcohol and ether, and acts so powerfully on the nervous system, that a single drop, placed on the tip of the tongue, will cause a violent headache to last for several hours. This liquid seems to have been almost forgotten by chemists, and it is only now that Mr. Nobel, a Swedish engineer, has succeeded in applying it to a very important branch of his art, viz: blasting. From a paper addressed by him to the Academy of Sciences, we learn that the chief advantage which this substance, composed of one part of glycerine and three of nitric acid, possesses, is that it requires a much smaller hole or chamber than gunpowder does, the strength of the latter being scarcely one-tenth of the former. Hence the miner's work, which, according to the hardness of the rock, represents from five to twenty times the price of gunpowder used, is so short that the cost of blasting is often reduced by 50 per cent. The process is very easy. If the chamber of the mine present fissures it must first be lined with clay to make it water-tight. This done, the nitro-glycerine is poured in and water after it, which, being the lighter liquid, remains at the top. A slow-match, with a well-charged percussion cap at one end, is then introduced into the nitro-glycerine. The mine may then be sprung by lighting the match, there being no need of tamping. On 7th June last, three experiments were made with this new compound in the open part of the tin mines of Altenburg, in Saxony. In one of these, a chamber, 34 millimetres in diameter, was made perpendicularly in a dolomitic rock, 60 feet in length, and at a distance of 14 feet from its extremity, which was nearly vertical. At a depth of 8 feet, a vault filled with clay was found, in consequence of which the bottom of the hole was tamped, leaving a depth of 7 feet. One litre and a half of nitro-glycerine was then poured in; it occupied 5 feet. A match and stopper were then applied as stated, and the mine sprung. The effect was so enormous as to produce a fissure 50 feet in length, and another of 20 feet. The total effect has not yet been ascertained, because it will require several small blasts to break the blocks that have been partially detached by this.

For the Journal of the Franklin Institute.

Apparatus for Illustrating Force.

Let $abco$ and $dfeo$ be two parallelograms, each side of which is five times as long as the short diagonal fo or bo . Now, if two pressures, do , eo , each equal to 5 pounds, be imparted at the same instant to the *rigid* body o , their joint effect upon it will be equal to that of a single pressure, fo , of 1 pound. This is easily proved by *experiment*; for if from an inelastic string, ac , we suspend a weight of 1 pound, we *see*, by means



of spring balances at a and c , that there is a strain of 5 pounds along the direction of each line, $a o$, $c o$.

Again, if a moving force, $d o$, sufficient to move the body 5 feet, from o to c , in a given time, and a moving force, $e o$, sufficient to move the body 5 feet, from o to a , in the same time, be both imparted at the same instant to the rigid body, o , their joint effect upon it will be equal to that of a single moving force, $f o$.

Now, what I desire to know is, whether there is not some method of exhibiting to the *eye* the reverse of this last fact? What philosophical apparatus can I employ to show that the same amount of force which will move a body through a distance, and in the direction $o b$, of 1 foot, will, in the same time, move two bodies, each equal to one-half of the body o , through distances, in the directions $o a$ and $o c$, each equal to 5 feet? I presume that apparatus for the elucidation of so important a principle must be in use in some of our institutions of learning, and a description of it would greatly oblige W.

Researches on the Vacuum. By HERMANN SPRENGEL, Ph. D.

From the Journal of the Chemical Society, January, 1865.

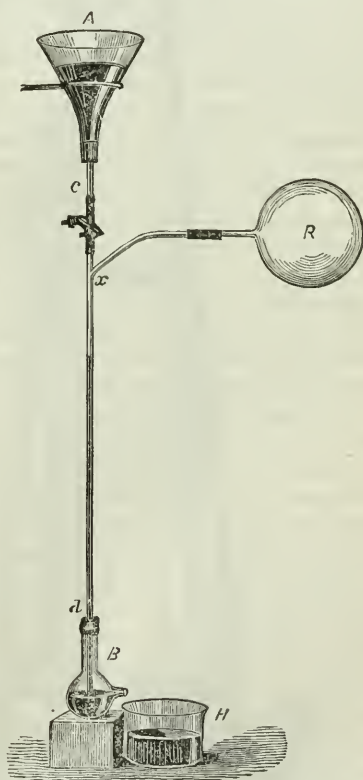
1. *The Instruments.*—The methods hitherto proposed for producing a vacuum may be divided into two classes, the mechanical and the chemical. A gas which fills a space may either be removed mechanically, or it may be converted, by taking advantage of its chemical or physical properties, into a non-gaseous, tensionless body. As, however, our atmosphere, from its general presence, is for the most part the only gas which has to be considered when a vacuum is to be formed, and as the reduction of its constituents to the non-gaseous form is attended with peculiar difficulties, I am inclined to consider that all practical methods of producing a vacuum may be regarded as mechanical. Atmospheric air may, in fact, be expelled from a space, first, by a solid body; secondly, by a liquid; and, thirdly, by a gas; which afterwards takes either a liquid or a solid form. Perfect vacua have hitherto been obtained only by this last method, but with such attending difficulties, that it appeared to me highly desirable to improve the other two, which afford greater facilities of working. The displacement of a gas by means of a solid or a liquid body is effected by instruments, commonly called air-pumps. The exhausting syringe of Otto von Guericke, with its piston, is the type of one class of these instruments, while Toricelli's barometer, with its column of mercury, is the type of the other class. The invention of the common air-pump was a consequence of Toricelli's vacuum, and it is partly due to this, that the degree of exhaustion attained by it has been, up to the present day, compared with Toricelli's vacuum as the standard of perfection. Hence it has followed that physicists have from time to time attempted to use Toricelli's vacuum as a receiver, or, in other words, to fill receivers with mercury, and attach tubes to them as long as those of barometers, through which the mercury was allowed to run off. All so-called mercurial air-pumps are based upon this principle,

and differ very little from the famous experiment which Toricelli made 220 years ago.

This, however, is not the only way in which the case may be viewed. If the top of a barometer were knocked off, the air would enter and the mercury would sink, or, what is the same, the mercury would sink and draw in the air. If, however, the experiment be so arranged as to allow air to enter, together with the mercury, and in such a manner that the supply of air shall be limited, while that of mercury is unlimited, the air will be carried away, and a vacuum produced. It is upon this principle that I have constructed a pneumatic machine, of which Fig. 1 represents the simplest form.

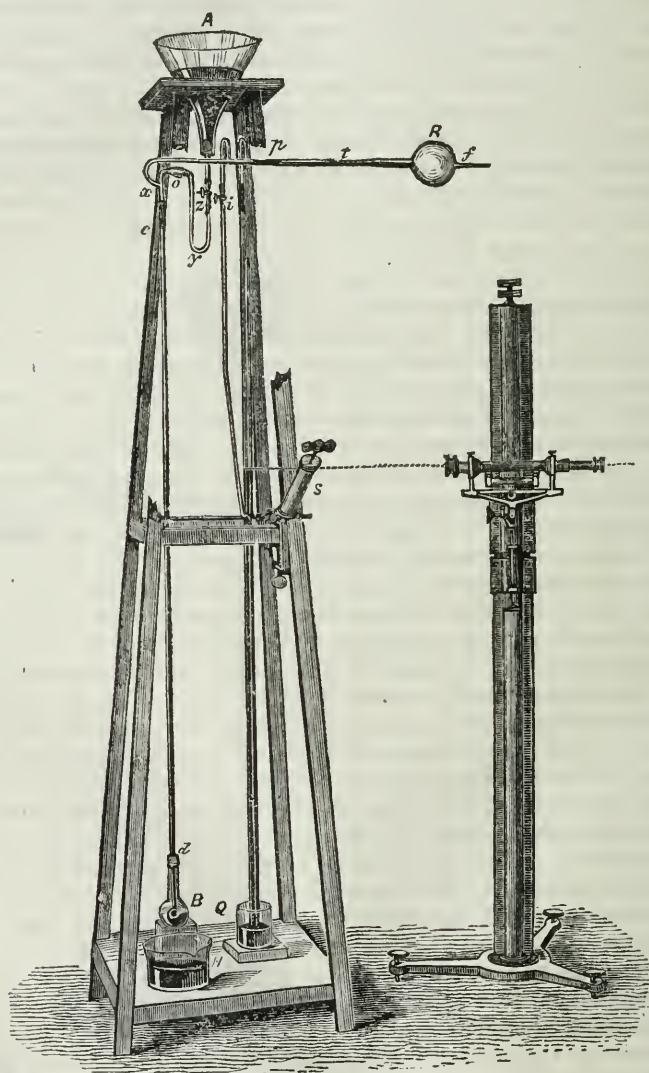
cd is a glass tube, longer than a barometer, open at both ends, and in which mercury is allowed to fall down, supplied by the funnel A, with which the tube is connected at *c*. The lower end *d* of this tube dips into a small glass bulb B, into which it is fixed by means of a cork. This glass bulb has a spout at its side, situated a few millimetres higher than the lower end of the tube *cd*. The first portions of mercury which run down will, consequently, close the tube, and form a safeguard against the air which might enter from below if the equilibrium should be disturbed. The upper part of *cd* branches off at *x* into a lateral tube, to which the receiver R is affixed. As soon as the stop-cock at *c* is opened, and the mercury allowed to run down, the exhaustion begins, and the whole length of the tube, from *x* to *d*, is seen to be filled with cylinders of mercury and air, having a downward motion. Air and mercury escape through the spout of the bulb B, which is above the basin H, where the mercury is collected. This has to be poured back from time to time into the funnel A, to pass through the tube again and again, until the exhaustion is completed. As the exhaustion is progressing, it will be noticed that the enclosed air between the mercury cylinders becomes less and less, until the lower part of *cd* presents the aspect of a continuous column of mercury, about 30 inches high. Towards this stage of the operation, a considerable noise begins to be

Fig. 1.



heard, similar to that of a shaken water-hammer, and common to all liquids shaken in a vacuum. The operation may be considered completed, when the column of mercury does not enclose any air, and when a drop of mercury falls upon the top of this column without enclosing the slightest air-bubble. The height of this column now corresponds

Fig. 2.



exactly with the height of the column of mercury in the barometer, or, what is the same, it represents a barometer, whose Toricellian vacuum is the receiver R.

Fig. 2 represents the actual instrument with which I am in the habit of working. The funnel A, supported by a wooden stand, serves as the reservoir for the mercury. By means of the tube *z y x*, it is connected with the tube *c d*, which I call the "fall-tube," so that the mercury will run down, as soon as the clamp *z* is opened, which compresses a caoutchouc tube inserted there. The tube *x p* leads to the receiver which is to be exhausted, and is in connexion with two tubes, one of which is attached to the common exhausting syringe *s*, while the other, serving as a gauge, dips into a glass of mercury containing a barometer. When the instrument is at work, the rising of the mercury in this gauge will consequently show the degree of exhaustion. The exhausting syringe is merely attached as an auxiliary to accelerate the operation, because the fall-tube, for a reason to be presently mentioned, must be of a thin calibre. The greater portion of air is more quickly removed by the syringe, and after this has been done, as much as possible, and the connexion between the receiver and the syringe has been broken off by compressing an inserted caoutchouc tube with the clamp *i*, the remainder of the air is carried off by the running mercury. The bulb B and the basin H are exactly as in Fig. 1. The instrument is about 6 feet high, so that the mercury collected in the basin H can easily be poured back into the funnel A. The use of a pump would facilitate the raising of the mercury, and prevent the admixture of air. This latter inconvenience may, however, be pretty well overcome by gently pouring the mercury on a glass plate, floating on the surface of that in the funnel. Should a few air-bubbles attach themselves to the side of the funnel, it may be best to remove them by means of a wire or a glass rod, though they are not, perhaps, of much consequence, as they are not observed to pass along with the mercury. The connexions between the glass tubes are made of well-fitting black vulcanized caoutchouc tubing, sold under the name of "French tubing." This is free from metallic oxides, which render the tubing porous. Besides this, all these joints are bound with coils of copper wire, which is easily accomplished with a pair of pliers. Moreover, the space between the inside of the caoutchouc tubing and the outside of the glass tubing is filled with a resinous cement made of fused caoutchouc. To prevent this substance soiling the interior of the instrument, I first, after having put the instrument together, tie the caoutchouc joint with the copper wire, and then turn back the end of the caoutchouc tubing over the coil, coat the inside of the end with cement, and turn it back again into its proper position. From this it is obvious that the fused caoutchouc can only penetrate as far as the copper wire coil. The connexion of the funnel with the tube *z y o* is made by means of a perforated caoutchouc cork. (These corks are easily made from a flat block of caoutchouc, cut out with a sharp Mohr's cork borer, well lubricated with oil.) When the instrument has been put together in this manner, it is ready for use. At first, the mercury is allowed to enter the fall-tube in such quantities as to raise the mercury in the gauge as quickly as possible. When, however, the operation approaches its completion, which is shown by the

rattling noise, it will be found useful to lessen the supply of mercury, and to let it fall down, drop by drop, on the column of mercury in the lower part of the fall-tube, and to proceed in this way till the exhaustion is completed. I am not able to give any definite statement as to the quantity of mercury to be employed, as it is obvious that a small quantity, say an ounce or two, is capable of exhausting a receiver of an indefinite size, if this mercury is only made to pass the fall-tube often enough; but I may remark that I have found 10 to 15 lbs. of mercury a convenient quantity to work with.

In my endeavors to find out how to construct the instrument, in order to exhaust a receiver with the greatest economy of time and mercury, I have not met with satisfactory results. There, of course, exists a certain relation between the amount of air to be exhausted, the quantity of mercury to be employed, and the time of the operation. In order to make the instrument act at all, the supply of mercury must be at least so large that the fall-tube may become closed, *i. e.* the running mercury may form drops of a cylindrical shape, breaking off the communication between the receiver and the external air. As the supply of mercury is increased, the rapidity with which the air is carried off also increases. But this soon reaches its limit, as, should the mercury be admitted too rapidly into the fall-tube, it gains the preponderance and closes the aperture at *x*. The most favorable conditions under which the instrument might be used are those where the mercury is made to fall down, drop by drop, enclosing between every two drops as large a portion of air as possible.

Volume may be increased by extension either in height or in breadth. If the fall-tube be lengthened, the bulk of the enclosed air will be increased, and the time required to produce exhaustion will be shortened, without increasing the weight of mercury employed. But as it is inconvenient to have the instrument higher than the height of a man, I attempted to increase the second dimension, *viz*: the width of the tubes. I soon found, however, that it was difficult, if not impossible, to close tubes of more than a certain width by single drops. In order to close a wide tube with a cylinder of mercury, (or any other liquid,) the mercury (or this other liquid) must run in freely and not in drops, for the simple reason that drops cannot be formed of the diameter of the calibre of the tube. The size of the drops depends upon the specific attraction of the molecules of the liquid, the form and surface of the vessel from which the liquid drops, the attraction existing between the liquid and the vessel, and the resistance offered by the greater or less density of the air through which the drop falls. I have not been able to form in a vacuum drops of mercury larger than about 3 millimetres in diameter.

Having failed in the use of a wide fall-tube, I endeavored to effect my object by the use of several small fall-tubes. Here, however, another obstacle offered itself. It is exceedingly difficult to regulate the flow of mercury so evenly that exactly the same quantity shall run down in each separate fall-tube, and I have found in practice

that unless the flow of mercury can be so regulated, simultaneous action cannot be obtained in the fall-tubes.

From these experiments, I have found myself unable to produce a vacuum as quickly as with a common exhausting syringe, unless by the employment of inconveniently large quantities of mercury at a time. If speed is required, I think the fall-tube should have the addition of the exhausting syringe, which will take away more quickly the larger quantity of air and leave to the running mercury only the task of completing the exhaustion. By such a combination, however, the instrument loses much of its simplicity, and offers, by its numerous joints, a far greater chance of leakage. For this reason, where time is no object, it will be preferable even to do without the gauge and to use the instrument in its simplest form, as represented in Fig. 1. The operator will soon learn from observation of the way in which the drops fall down when the exhaustion is completed. Without the auxiliary air-pump, the exhaustion of a receiver of the capacity of about half a litre will take from 20 minutes to half an hour. Though this may appear to be a long time, I have no doubt this method will be found, after all, the quickest and simplest for producing a vacuum as nearly perfect as I have been able to produce.

The slowness of the action is obviously due to the smallness of the bore of the fall-tube. As soon as the calibre of this tube is increased, the time of the operation rapidly decreases; for the contents of two cylinders of the same height are to each other as the squares of their radii, and the time of the operation ought to decrease in the inverse ratio. The proper size of the bore of the fall-tube is $2\frac{1}{2}$ to $2\frac{3}{4}$ millimetres. As soon as I exceeded this limit, I invariably found the vacua less perfect. It is not difficult with these wider tubes to raise the mercury in the gauge to the height of the barometric pressure, minus 1 or even $\frac{1}{2}$ millimetre; but I have not been able to obtain with them vacua so near perfection, as I have been enabled to obtain by the use of fall-tubes of $2\frac{1}{2}$ millimetres calibre. The explanation of this fact must be sought for in the size of the drops, which, as it appears to me, must, in falling down, exercise a certain pressure against the side of the tube, thereby preventing the denser air underneath the drop from finding its way again to the part of the tube above the drop, where the air is more rarefied. I have not obtained better vacua by the use of fall-tubes of a calibre less than $2\frac{1}{2}$ millimetres.

Before I proceeded to test the efficiency of the instrument, I directed my whole attention to the construction of air-tight joints. In this, however, I did not succeed. It is a well-known fact that barometers become inaccurate in time, as air finds its way into the Toricellian vacuum between the glass and the mercury enclosed in it. The vacuum in my instrument is, of course, exposed to the same sources of imperfection. (To offer a greater resistance to the air, which might enter from the funnel, I have given to the tube *xyo* the form of a U-tube.) Leakage, however, happens in a far less degree from this cause than from the imperfection of the caoutchouc joints. Among the numerous

modifications I have tried, I consider the one which I have before described as the most practicable. With this joint the mercury in the gauge does not sink more than about $\frac{1}{2}$ millimetre in 24 hours. Williamson and Russel,* in constructing their admirable apparatus for the analysis of gases, have met with the same difficulty, and I am able to corroborate their statements. The porosity of solid bodies is astonishing, and one is almost compelled to think that glass vessels are the only ones impenetrable to gases.

The following degrees of exhaustion have been made with cold mercury, which had merely been filtered through paper to free it from visible impurities, but which had never been dried nor freed from air by special means. I have worked with heated mercury, (100 to 150° C.,) but have not noticed much difference in the perfection of the vacua. Even if some slight advantage could be obtained by it, its use would be objectionable, practically speaking, from the risk of endangering the health of the operator. When the mercury is heated and allowed to run down quickly, the instrument is at the same time converted into a sort of electric machine. In the dark flashes of electric discharge are seen to light up the exhausted tubes, and sparks may be drawn at intervals from the basin in which the mercury collects, as from an electrophorus. The fall-tube invariably becomes soiled after some time by some impurity in the mercury, and particularly after the employment of heated mercury. I attribute this to the oxidation of the mercury, arising from this electric action, which must be favorable to the formation of ozone. I have to mention that, to attain high vacua, the fall-tube must be clean as well as the mercury.

The length of the fall-tube in the instrument before us is calculated for the use of a liquid having the specific gravity of mercury. Of course, as the specific gravity of the liquid employed becomes less, the fall-tube must be longer. Practically, however, water is the only liquid that need be considered in place of mercury, and I have no doubt that an instrument adapted for water would furnish a simple and most efficient exhausting machine. It is not unlikely that such an instrument might possess advantages which air-pumps of other constructions have not, particularly in hilly countries, where the large volume of a natural water-fall might be rendered available.

I now come to consider the way in which this instrument acts. It is obvious that it stands in a near relation to the *trompe* or *Catalonian bellows*, the old and well-known contrivance for producing a blast. My instrument is merely the reverse of the *trompe*, with this addition, that the supply of air is limited, while that in the *trompe* is unlimited. The theory which explains the action of the *trompe* will, at the same time, explain the action of my instrument. The theory of the *trompe* has repeatedly been treated by distinguished philosophers, as Venturi, Magnus, Buff, and others. It would lead me too far to enter upon a criticism of their opinions, which appear to me partly erroneous, partly not to the point. In my opinion, the action of both instruments may, in all cases, be satisfactorily deduced from Kepler's law of the uni-

* Chem. Soc. J., [2,] ii., 238.

formly accelerated motion of bodies. When the clamp z is opened, only a certain and almost uniform quantity of mercury (or any other liquid) can pass at a given time. As soon as a particle of mercury has arrived at x , it is under the influence of the general law of gravitation. It must sink and move with uniformly accelerated velocity. The same may be said of the second or third particle of mercury; but while the second one is starting, the first one has accomplished a portion of its way, and when the third is starting, the distances between one and two and two and three are not equal, but unequal. A vacuum must, therefore, have been formed between them, and hence the tendency of the air to restore the disturbed equilibrium, *i. e.* by rushing in, if the instrument is open, or by expanding, if a receiver is attached. If the tube into which the liquid runs is larger than the column of liquid which the atmospheric pressure can support, the air in the receiver will, of course, expand to its last degree. If the mercury is allowed to fall down in $c d$ in drops, it will act in exactly the same manner as the piston in a common air-pump. These drops are, so to speak, liquid pistons.

The chief excellence of this instrument appears to me to be its simplicity and the great perfection with which it performs its work. To ascertain the degree of exhaustion, I had at first to resort to a comparison with the barometer, but I have not been able to make a barometer in which the mercurial column stood higher than in the gauge of my instrument, though the barometers were constructed with care, and the readings made by means of a cathetometer. Though my instrument was not air-tight, and consequently not perfect, this apparent equality of the levels in the gauge and in the barometer is easily accounted for, upon reflection, by the fact that the human eye is not able to distinguish between $\frac{1}{100000}$, or even $\frac{1}{10000}$ part of a millimetre. But being curious to see how much the instrument, even in its present imperfect state, can do, I have taken particular pains to ascertain it. I have tried different ways, but I will describe only that which appears to be the best and most efficient. It is simply the application of Dumas' method for the determination of vapor densities. I took a receiver of the form R, (Fig. 2,) a bulb extended on both sides into a capillary tube, one of which was open and attached to the instrument, while a portion of the other was broken off and the aperture sealed. The part taken off, and having, consequently, the same calibre as the portion left attached to R, was preserved. The receiver was now exhausted and taken off by sealing it at A. This point was broken under the mercury which had just run through the instrument. I did this to meet the objection, that boiled mercury might absorb the remainder of the air in R, while, on the other hand, mercury containing more air might give off some of it and allow it to enter the vacuum. If, now, the receiver had been perfectly exhausted, the mercury would have filled it completely. This, however, was not the case, a very small air-bubble always remaining at the end of the sealed capillary tube. The capillary tube was broken off at f , and the mercury contained in R was collected and weighed. Into the capillary tube, first broken off

from the receiver, I now introduced by suction a small particle of mercury of exactly the same length as the particle of air in *f*. This mercury was then placed in a delicate balance and weighed. The weight of this particle of mercury bears the same proportion to the weight of mercury in *R* as the weight and volume of air remaining in *R* after exhaustion bears to the weight and volume of air in *R* before exhaustion. The highest proportion I have attained in this way is $\frac{1300}{1000000}$, and upon the average I consider it not a difficult thing, with the present means, to exhaust a receiver to $\frac{1000}{1000000}$. From this it is obvious that a barometer may be made by simply exhausting and sealing a tube, one end of which is then broken under mercury. I have actually made some in this way.

I have applied the finest reaction for the presence of gases, viz: the absence of any electric discharge in a perfect vacuum.* The few tubes I have made hitherto always showed a slight discharge, which, however, I have chiefly attributed to the presence of mercurial vapor, though I could have ascertained it by means of spectrum analysis. I have tried to remove this vapor by introducing between the instrument and the electrical tube, a tube exposed to a cold of -10° C., or filled with finely divided gold or freshly ignited charcoal, but the intensity of the whitish-green electric light appeared to be not much diminished by these means. From this I infer that the mercurial vapor has either not been condensed, or the supporter of light is due to another body. Being aware of the subtlety these experiments require, and of my shortcomings in their performance, I should not like to say more about them now, but I hope to repeat and study them with care hereafter. At any rate, I have learned this much, that during the exhaustion with my instrument, the colors of the electric discharge change from intense red and blue to faint white and green; that I have passed the limit at which the density of the air is most favorable to the electric discharge; that the stratifications are exhibited in an admirable manner, and that the instrument will prove useful for the performance and study of these experiments, which, on account of their beauty, have excited so large an interest.

Before concluding this paper, I should like to say one word more about the theory of the action of the instrument. Is the action entirely due to the accelerated velocity of the mercury and the elasticity of the air? I answer: yes. Struck by the extraordinary attenuation of the air, and misled by Venturi's theory, I was at first much inclined to attribute the action partly to two other agencies: the attraction of gases to liquids, and their absorption by liquids. But the following experiments showed me that I was mistaken: I forced water through short T-pieces at different velocities, using from a slight pressure up to that of several atmospheres, and I have not been able to raise water in a tube connected with the other branch of the T-piece to a greater height than that corresponding to the length of the tube from which the water was expelled. But this does not show so much as the fact, that when the calibre of the fall-tube is larger than $2\frac{1}{2}$ millimetres, it

* Gassiot, *Phil. Trans.*, 1858-59.

is impossible to raise the mercury in the gauge so high as it stands in the barometer, however long the mercury may be allowed to run, and whatever quantity may be used. This shows that the action is entirely mechanical; that the air expands and is cut off, portion by portion, by the falling drops of mercury, and that when the air is highly attenuated, these drops must entirely fill the tube, and even exercise a slight pressure against the sides of the fall-tube, otherwise the action will cease, as in a common air-pump, through the non-action of the valves.

I am under the impression that the use of better materials, and the application of greater skill than I have hitherto employed, will be followed by still better results, and will not improbably furnish instruments capable of producing vacua perfect to our senses; and even if we should not succeed in making a perfectly air-tight joint, the end will still be attained, if we can only succeed in carrying off the air more quickly than it can enter. At any rate, the immense elasticity of air is here displayed in a striking manner, and there is a very wide interval between the attenuation of 1,300,000, to the density of gases which must exist in the powder-chambers of cannons or mines at the moment of explosion. Another striking fact is that exhaustion of $\frac{1}{1000000}$ has been made with cold common mercury, doubtless containing a considerable quantity of air and moisture, which one would expect to be set free and enter the vacuum as soon as the mercury so violently agitated passes along the fall-tube. But the particles of these absorbed gases, which are set free on boiling, must, at common temperatures, be so intimately connected with the mercury that their expanding or gaseous properties are lost, as in the oxygen of oxide of mercury.

The main fact which I have established in this paper may be shortly stated to be that, *if a liquid be allowed to run down a tube, to the upper part of which a receiver is attached by means of a lateral tube, and if the height at which the receiver is attached be not less than that of the column of the liquid which can be supported by the atmospheric pressure, a vacuum will be formed in the receiver, minus the tension of the liquid employed.*

The properties of highly rarefied gases, and the conditions of that remarkable space in which there is *nothing*, have hitherto been scantily examined, though this subject is suggestive of interesting questions, the solution of which I hope to treat of in my further investigations that border on the, so to speak, negative side of natural philosophy.

The above experiments* were performed in the laboratory of St. Bartholomew's Hospital, and I am glad to have the opportunity of acknowledging most gratefully the facilities which have been offered to me by Dr. Odling in the prosecution of them.

* Communicated to the Chemical Society, June 16, 1864.

On some of the most Important Chemical Discoveries made within the last Two Years. By Dr. F. CRACE CALVERT, F.R.S., F.C.S.

(Continued from page 342.)

[From the London Journal of the Society of Arts, No. 673.]

I shall now have the pleasure of calling your attention to an interesting and valuable invention of one of the most learned and eminent chemists of England, Dr. J. Stenhouse, F.R.S., who has devised quite a new method of water-proofing vegetable and animal tissues and fabrics. Previously to his discovery, the modes of water-proofing consisted in using beeswax and various kinds of drying oils, such as linseed, the siccation of which is enhanced by boiling them with peroxides of lead or manganese. Further, you are all aware of the extensive use which has been made of caoutchouc and gutta percha for water-proofing purposes. Dr. Stenhouse's water-proofing material is a white, solid substance, having no odor, undergoing no change through the action of the atmosphere, and which has acquired of late great popularity, by the application which has been made of it as an illuminating and lubricating agent—I mean paraffin, the discovery of which, in a commercial point of view, and its introduction into public notice, are due to Mr. James Young of Bathgate, near Glasgow, who has now established one of the largest manufactories in the world for the production of this article, notwithstanding it was considered a commercial novelty in 1852. Dr. Stenhouse found that if he employed pure paraffin for water-proofing, owing to its tendency to crystallize, it would not adhere sufficiently to fabrics. He therefore conceived the happy idea of adding to it a few per cent. of linseed oil, which overcame the defects presented when paraffin was employed alone, effecting a better adhesion between the water-proofing material and the textile fabrics, and rendering leathers more flexible. Dr. Stenhouse melts together paraffin oil with a few per cent. of linseed, as above stated. He runs the whole into cakes, and, in order to apply this water-proofing agent, he beats the cake and rubs the materials over with it, or spreads the melted mixture over the fabric by means of a brush. His process is applied with great advantage by Messrs. Silver & Co., to the water-proofing of soldiers' tents, and other materials of that class, to the great comfort of the soldiers, for, without increasing the weight of their tents, it renders them impermeable, and protects the men from rain and its attendant discomfort and danger. Another most useful application of Dr. Stenhouse's water-proofing material is the rendering of leather impermeable. By examining the specimens you will immediately see the immense advantage that cavalry will derive from having their saddles rubbed over with this preparation, as it renders the leather incapable of absorbing moisture, and enables the soldier to mount his horse after heavy rain with as much comfort as if it had remained under shelter. It also renders the soles of shoes quite impermeable, and at the same time communicates to them great flexibility, so that the boots of navvies, and other similar articles, are rendered far more useful and durable, as we all know that the constant

wetting and drying of leather expedites, in a marked manner, its decay. There is one more application of Dr. Stenhouse's water-proofing, to which I should wish to call your especial attention, as it is of interest to the manufacturers of Manchester and of Lancashire generally. In those districts large quantities of what is called water-proofing materials are used in packing the goods, and preserving them from external wet or injury. Many of these materials are made by covering a coarse calico fabric with a coating of boiled linseed oil; but this class of packing is very imperfect, and loses its strength rapidly, especially in hot climates, owing to the fact that the boiled oil absorbs oxygen, and carries it on to the fibre, oxidizing it, and thereby soon destroying its tenacity. By applying Dr. Stenhouse's process to the fabric, previously to the drying oil, not only is great impermeability attained, but the fibre, being saturated with paraffin, is preserved from the subsequent oxidation which it would undergo, under the influence of the atmosphere, in the presence of the boiled oil alone.

I should have wished to have dwelt at some length on the interesting application which has been made of late years, especially on the Continent, of another coal product, which, like most of those whose origin is due to coal, has received many valuable and beautiful applications. The one I now refer to is called bisulphide of carbon, and is applied with great success, not only to the extraction of fatty matters from various seeds and fruits, such as olive, linseed, &c., but in Algiers for extracting from flowers various essential oils, commonly called perfumes, such as essence of roses, lavender, jasmine, &c. You will, no doubt, remember also the useful application which bisulphide of carbon receives in the hands of Messrs. Allbright & Co. of Birmingham, in separating the common phosphorus from the red or amorphous phosphorus now applied to the manufacture of chemical matches, as explained to you in my first lecture of last year's course.

I cannot conclude what I have to say respecting coal products, without stating the fact that, since I had the honor of delivering a lecture in this room, in 1862, many beautiful and valuable discoveries have been made in connexion with coal tar colors. Dr. A. W. Hoffman has succeeded in obtaining some magnificent purples, by a process as curious as it is highly scientific, and such as might be expected from so talented a chemist. Since then a splendid green color called verdine, and which has the curious property of retaining that color in artificial light, yea, more than that—of increasing in beauty in the presence of that light—has been discovered by M. Eusebe. A beautiful fast black, easily applicable to the art of calico printing, has also been devised; and, lastly, in the hands of Messrs. Simpson, Maule, and Nicholson, the well known color called magenta, and a beautiful blue called opal, have not only been much increased in beauty, but their cost of production has been materially reduced. In fact, at the present day, every shade of color is produced from coal tar products; but the subject is too vast for me to attempt now to enter into details as to their mode of production and application.

As the hour is advancing, I must, though with regret, leave the in-

interesting subjects which have reference to coal and its products, and pass to another class of manufacture. The first of these has reference to the refining of sugar, and among the several improvements which have been effected in this branch of manufacture during the last few years, none is more important in its general bearing than that recently brought to the notice of the public by Mr. Alfred Fryer, of the well-known firm of Fryer, Benson & Foster, of Manchester. This gentleman has published some valuable information on the composition of the sugar-cane juice, and the alterations it undergoes under the influence of heat and atmospheric air, and has conferred on the colonies a great boon by inventing an apparatus which will effect a great saving in obtaining sugars. Mr. Fryer's experiments on the cane juice teach us that, instead of only extracting 49 per cent. of the juice, as is usually the case, when the canes are worked by the old system, 61 per cent. can be obtained with a good steam engine having 24 inch rollers; and by pressing the megass a second time through the rollers as much as 70 per cent. can be obtained; and Mr. Fryer does not doubt that even 80 per cent. may be reached, if more attention is paid to the pressing of the canes through the rollers. Mr. Fryer has also published some interesting facts on the action of the oxygen of the atmosphere on cane juice. Thus he has observed that the juice rapidly darkens, and that this increase of coloration is not only an indication that the juice is undergoing deterioration, but that no amount of defecation will subsequently remove this coloration. He has further noticed that cane juice rapidly becomes acid, and the acidity increases also in a very rapid manner. He gives an instance—a pattern of too many others—where the juice, after expression, flowed down a spout 250 feet in length, from the mill to the boiling house, occupying in its descent about half a minute. The amount of acidity increased from 100 to 253, and the color deepened four-fold.

Mr. Fryer has also published some very interesting facts on the influence of heat on the cane sugar, and I here take the liberty of extracting from a paper of his the following facts:

“We now come to the boiling. All heat above 140° is capable of exerting an injurious effect. As regards the time, this effect is proportionate to the duration of the heat; the continuance of any syrup for two hours, at any given temperature, would cause just double the mischief which would be produced by its continuance at the same temperature for an hour. But as regards the heat, the mischief increases about as the square of the difference from 140° the highest innocuous temperature. So, at 160° , during any given time a certain degree of mischief would be done. To keep the same syrup for the same time at the heat of 180° , would give four times the mischief; at 200° , nine times; the difference of 180° from 140° being twice as great as that of 160° , and that of 200° being three times as great.”

This mischief consists partly in the change of color, partly in the change of a quantity of cane sugar or sucrose into fructose. Both these kinds of sugar are present in all neutral saccharine solutions. Sucrose is the ordinary crystallized cane sugar; fructose exists more

especially in some kinds of fruit, such as grapes, gooseberries, cherries, oranges, &c., which refuse to form well-divined crystals. Further, I should remark that, under the influence of heat, as just stated, cane sugar or sucrose, is converted into grape sugar or fructose, and that the presence of fructose interferes in a most extraordinary manner by preventing the free crystallization of sucrose. Thus, for example, every particle of fructose in a mixed solution detains from crystallization its own weight of pure sugar. In fact, it would be impossible, after mixing equal weights of loaf sugar and fructose in a solution, to recover the former in a crystalline state. The change produced by the atmosphere alone, without the action of heat, shows the necessity of proceeding instantly to raise the temperature to the boiling point, and the concentration should be continued without loss of time. The temperature should not, however, be raised beyond the lowest effectual heat.

I will now call your attention to Mr. Fryer's "concretor," as he terms the apparatus. It consists of inclined corrugated plates, over which the juice flows.

From the further end of the cylinder a pasty mass is discharged, and, in cooling, it hardens into a non-crystalline homogeneous substance likely to be long known as Fryer's "concrete." Its material is simply cane juice deprived of its vegetable albumen and water, and, not being contaminated by molassas or caramel, is admirably fitted for the operations of the refiner, and will, therefore, command his attention. Allow me, further, to add that his process is easy to conduct; the apparatus, as you see, is simple and self-acting, not liable to derangement; that it performs a large amount of work, and therefore proves a material saving to the sugar producer. I cannot conclude my remarks on Mr. Fryer's invention, as applicable to the Colonies, better than by repeating here the words expressed by the Governor of Antigua, who said: "I believe firmly that you have opened a new era of prosperity to our Colonies, and heartily wish you abundant success in the course on which you have entered." As to the advantages which a sugar refiner in this country will derive from employing Mr. Fryer's "concrete," instead of having to refine the molassas and coarse sugars usually imported into this country, they are so obvious that it would be really a loss of time to enlarge upon them. The saving to the refiner in having nearly pure sugar to operate upon, and not having to contend with the removal of color, converted sugar, caramel, and other impurities, will at once convince you of the support and approbation the article will receive from the sugar refiner.

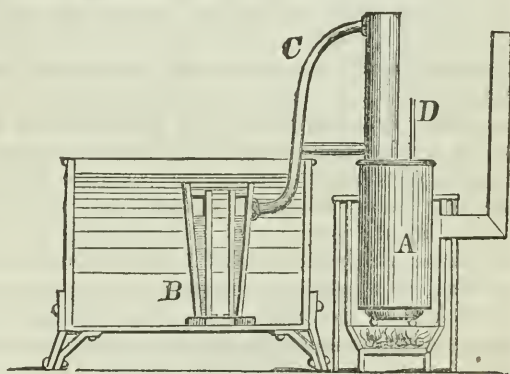
If, at the commencement of this lecture, I draw your attention to the value of intense heat produced at a small cost so as to enable our manufacturers to carry on their various processes, it now becomes my duty to inform you that of late years the cheap production and application of low temperatures has become a necessity, especially since organic products have been manufactured on an extensive scale. Three different machines for obtaining these low temperatures have

been brought to public notice, viz : First. That of Mr. Kirk, who has applied in a beautiful manner some of the physical laws discovered by Dr. J. P. Joule and Professor W. Thomson, in their researches on the mechanical theory of heat. Thus, Mr. Kirk succeeds in producing a low temperature by condensing under high pressure atmospheric air, which, on being allowed to resume its primitive volume, produces cold, for the compressed air cannot resume its primitive volume without the essential element for its expansion, namely, heat; and if the apparatus is properly contrived, which is the case in that of Mr. Kirk's, the heat necessary for the expansion of the compressed air is supplied to it by the body whose temperature is to be lowered. Although the construction of this machine is exceedingly costly, still it has been employed at Mr. James Young's works at Bathgate, with great success to the cooling of paraffin oil to extract from it the solid paraffin which it contains. The second apparatus is that of Messrs. Harrison & Co., of London, who employ ether as the medium for producing low temperatures. The third is that of M. Carré—in my opinion the cheapest and most practicable apparatus yet invented for the purpose, the more so that it is applicable for household as well as for manufacturing purposes. Although I, like many of you, have witnessed the production of ice by it at the late exhibition, still I was not prepared to learn that it could be applied with economy to the extraction of some of the salts existing in sea-water. Still, such is the fact. M. Ballard, a well known French chemist, after many years of study and labor, succeeded in extracting from sea-water two products, which play a most important part in most of our large chemical works, viz : sulphate of soda and chloride of potassium. To produce the first, under ordinary circumstances, extensive works are required, such as are found at St. Helen's, and Newcastle-upon-Tyne, where thousands of tons of common salt are acted on by vitriol, which gives rise to muriatic acid and sulphate of soda. As to the salts of potash, the French, as well as ourselves, are dependent for it upon the forests of Russia and the native forests of Canada. By M. Ballard's discovery, France will free itself from a dependence upon foreign supplies for the potashes she may require, as well as the sulphur, and will also do away with the public nuisance, namely, the conversion of common salt into sulphate of soda. Without entering here into details, let me state that M. Ballard operates as follows: In the early part of the spring season, considerable quantities of sea-water from the Mediterranean are run into large shallow reservoirs. In the summer season the water evaporates, a certain proportion of common salt separates, and the concentrated water is stored in other reservoirs until winter, when it is again allowed to flow back into the shallow reservoirs, where it yields, during a cold night, thousands of tons of sulphate of soda. The mother liquors from which the sulphate of soda has separated are allowed to flow into Carré's apparatus, where they are subjected to a comparatively intense cold, and yield large quantities of double chloride of magnesium and potassium, which, on being subjected to heat in a furnace, gives hydrochloric acid, magnesia, and

chloride of potassium. This application of Carré's apparatus, in this instance, shows the simplicity and practicability of it. It is based on rather a different principle to those of Kirk and Harrison. To obtain a low temperature he applies heat to a vessel which contains a saturated solution of ammoniacal gas. This drives off the gas, which is made to pass into a vessel surrounded with cold water, where it liquifies itself by its own pressure. If then the heat be removed from under the solution, its temperature will gradually fall, and it will become again susceptible of re-absorbing the ammoniacal gas, thus facilitating its evaporation from the vessel in which it has condensed, and, as it is necessary for the passage of the liquified ammoniacal gas into its gaseous form that it should absorb the heat from the surrounding medium, let it be water or any other fluids, their temperature will gradually decrease. The following diagram will enable you to understand better the working of this invention :

1. Before each operation incline the apparatus horizontally, and maintain it in the position about ten minutes. 2. Place the boiler (A)

Fig. 1.



in the furnace, and the refrigerator (B) in a bucket filled with cold water, so that the summit of the refrigerator be covered with two or three inches of water. A small quantity of oil is poured into the tube which is placed in the upper part of the boiler, in which also a thermometer is placed. The apparatus is heated moderately until it reaches 266° . The apparatus is then removed from the fire, and the boiler is placed in the bucket of cold water. The hole of the refrigerator being stopped with a cork, and the tin vessel surrounded with alcohol, having previously nearly filled it with water, the congelation takes place by the evaporation of the liquid ammonia in the condenser.

Although the evening is far spent, I cannot leave you without calling your attention to a very ingenious mode, devised by M. Pelon, for warming railway carriages during cold weather. You are too well acquainted with the present clumsy and expensive method now in use to require any description from me. The only remark I shall make upon it is, that it is the boon of those who are in least need of it, namely, first-class passengers, whilst those of the second and third classes have not that luxury supplied to them. To avoid loss of time, I shall not attempt to describe the various methods which have been proposed as substitutes for the one at present in use, but shall at once state that

M. Pelon's method is based on the conversion of force into heat, the heat in this case being generated by friction; and from what I stated in my first lecture you must be perfectly *au courant* of what is understood in the present day of the conversion of heat into force, and *vice versa*. All those persons who were fortunate enough to visit the French Exhibition in 1855 must have been struck with a machine, invented by Messrs. Mayer and Beaumont, which generated enough heat to convert water into steam and thus obtain a motive power; and this was effected without fuel or electricity, but by mere frictional heat, which they obtained by causing a wooden mandril surrounded with tow to revolve with great rapidity inside a copper cylinder which itself was surrounded with a small quantity of water. The great merit of the invention of these gentlemen, and which drew upon them the special attention of the Emperor, was that neither the towed mandril nor the copper cylinder were materially injured or deteriorated after many days working. This important end was attained by them by allowing a gentle flow of oil to run constantly through the cylinder, thus preventing immediate contact between the towed mandril and the copper cylinder. In fact, the frictional heat was produced through the friction which took place between the particles of oil themselves, preventing thereby all wear and tear. Notwithstanding the ingenuity displayed in this invention, still, as a means of obtaining motive power, it was useless, for more force was required to generate an amount of heat than could be yielded by the friction of the particles of oil. But in the application which M. Pelon has made of this invention to the heating of railway carriages, the motive power required to generate the heat being produced without cost to railway companies, as it is caused by the very act of the traveling of the carriages themselves, the cause which accounted for the failure of the principle as a practical mechanical application, namely, the production of the force required to work it is overcome. M. Pelon proposes to fix one of Messrs. Mayer and Beaumont's mandrils under each railway carriage compartment, and to convey the heat produced by the revolution of the towed mandril to the compartment itself by means of metallic conducting surfaces, which, in their turn, will heat the atmosphere of the compartment. We shall, I am happy to say, within a year or two, know if M. Pelon's invention will be capable of general adaptation, as it is now being practically tested on one or two of the French railways.

Thin Sheet Iron.—Protection of Iron from Rust.

From the London Chemical News, No. 319.

We have, on previous occasions, reported the successive efforts of British and foreign iron-masters in the direction of producing sheets of iron of extreme tenuity. On the occasion of the meeting of the British Association, in September last, some large and very perfect sheets of iron foil were shown at the works of Messrs. Lloyds, Fosters

& Co. of Wednesbury, which weighed two grains per square inch, and we have already described the laminated metal produced by Mr. Parry of Ebbw Vale, weighing only 1·5 grains per inch. Since then great progress has been made by several manufacturers, and sheets of iron have been prepared of the marvellous degree of tenuity indicated by the measurement of 4800 thicknesses, being equivalent to one inch. They were produced in the mills of Messrs. W. Hallam & Co., Upper Forest Tinworks, near Swansea, and are in the form of perfect sheets, measuring 10 inches by $5\frac{1}{2}$ inches, or 55 square inches, and weighing no more than 20 grains, or 0·36 grain per square inch. A noteworthy circumstance, in connexion with these thin sheets of iron, is their remarkable degree of permanence, or power of resisting the oxidizing action of the air. This protection is undoubtedly due to the continuity of the black fused layer of magnetic oxide with which these specimens are invariably coated, a fact which Mr. McHaffie of Glasgow has turned to useful account in a special furnace treatment, to which plates and other articles of wrought iron are subjected, for the purpose of securing increased protection against air and water. The operation consists merely in imbedding the iron plates in powdered hæmatite, or other native oxide of iron, and heating to full redness for several hours, when a perfect layer of the protective oxide is formed. The plates are then allowed to cool gradually, and are found to be especially well adapted to ship-building purposes. Mr. McHaffie, in his paper, also claims the use of oxide of zinc for producing an adherent black film, which, in this case, doubtless, consists of a true combination of the oxides of iron and zinc, possessing an equal, if not superior, degree of permanence to that which has been already mentioned.

Photographs on Paper in their Natural Colors.

From the London Journal of Science, April, 1866.

M. Poitevin has lately succeeded in producing photographs on paper in their natural colors. He prepares his sensitive paper in the following way: Having obtained a layer of violet subchloride of silver on the paper, by the action of light on the white chloride in the presence of a reducing agent, he applies to the surface of the paper a liquid composed of one volume of a saturated solution of bichromate of potash, one volume of saturated solution of sulphate of copper, and one volume of a solution containing five per cent. of chloride of potassium. This paper is dried and kept in the dark; it will keep good for several days. In this mixture the bichromate of potash is the principal agent, the sulphate of copper facilitates the action, and the chloride of potassium preserves the whites which are formed. In copying paintings on glass, the exposure to direct light need only last five or six minutes; but the time must, to some extent, depend on the transparency of the picture to be copied, and it is easy to watch the development of the image on the paper. The paper is not sufficiently sensitive for use in the camera. To preserve the pictures it is only necessary, first, to wash them with water acidulated with chromic acid,

then to treat them with water containing bichloride of mercury, afterwards with a solution of nitrate of lead, and, lastly, well wash them with water. After that they will not change in ordinary light, but will, however, turn brown in direct sunlight.

Magic Photography.

From the London British Journal of Photography, No. 312.

Such is the designation of the latest novelty in our art-science—a designation which we borrow from a sensational advertisement in one of the daily papers. Its nature may thus be stated: Two sheets of paper are supplied to the purchaser, together with instructions. One of these sheets is albumenized, the other is a sheet of blotting-paper. There is no picture visible on the albumenized paper; but when, in accordance with the instructions given, the sheet of blotting-paper is moistened by means of a few drops of water and pressed in contact with the face of the albumenized paper, a picture immediately springs into existence. The question now arises: How is this accomplished? Light has evidently nothing to do with it, seeing that the same phenomenon occurs both in sunshine and in comparative darkness.

The following is the method by which these “magic photographs” are produced: Print a picture on albumenized paper in the usual way, taking care not to print so deeply as ordinarily. Fix the print (without toning) in plain hyposulphite of soda, wash thoroughly, and then immerse it in a saturated solution of bichloride of mercury till the image disappears. Again wash thoroughly and dry. The paper now appears like a piece of plain albumenized paper, without any appearance of a picture on it, and in this condition it may be kept for an indefinite time.

To cause the image to appear instantaneously and in more than its pristine vigor, dip the paper in a weak solution of hyposulphite of soda; or, preferably, dip a piece of white blotting-paper in a solution of hyposulphite of soda and dry it. This prepared paper may be kept in contact with the latent picture so long as moisture is excluded. When it is required to develop the image, moisten the blotting-paper with common water and press it against the albumenized surface of the print, when, presto! the “magic photograph” is produced, and is, when washed, as permanent as many of the photographs of the present day. The image, by being again immersed in the bichloride of mercury solution, may be once more rendered invisible, and, by the hyposulphite solution, again restored as often as may be desired.

Although we believe that this process of magic photography has been patented a few weeks since, every intelligent photographer who has made himself acquainted with the past history of our art-science, knows that many years have elapsed since this “magic” process was first practised.

The amusement that can thus be introduced into the social circle by the “magic photographs” may be easily conceived.

New Process for Indigo Dyeing. By M. J. C. LEUCHS.*

From the London Chemical News, No. 330.

Before it can be used for dyeing, indigo must be rendered soluble in alkaline and caustic solutions by being treated by a reducing body. By this reaction indigo loses its color, but after being fixed on stuff and exposed to the air it absorbs fresh oxygen and returns to its original color. This process, theoretically so simple, is practically complicated by serious difficulties, and requires, on the part of the dyer, much practice and great dexterity. Thus, for instance, with indigo reduced by fermentation with vegetable matters, in a caustic solution, the various acids produced during the fermentation combine with the alkali, the liquid soon ceases to be caustic, and loses the property of dissolving the reduced indigo. To remedy this a fresh quantity of alkali (soda, potash, or lime) must be added from time to time; but should an insufficient quantity be added, a portion of the reduced indigo remains undissolved, and soon decomposes under the fermenting matter. If, on the contrary, an excess of alkali be added, a certain quantity of white indigo is lost by its combining with potash, and forming an insoluble product.

According to M. Leuchs, of Nuremburg, all these objections are obviated by effecting the change from blue to white indigo by pectine. Pectine consists in considerable quantities in the turnips of different species, in pumpkins, melons, &c.; it may be extracted from these fruits, or they may even be directly used to reduce indigo. The most simple process consists in heating 45 or 50 kilogrammes of the caustic ley to 75° C., adding half a kilogramme of well pulverized indigo, then suspending in the vat a kind of basket of iron wire, containing from 8 to 10 kilogrammes of fresh turnips, cut into small pieces. Then heat gradually to boiling point; the indigo soon loses its color, and the solution decanted into special vats and diluted with water freed from air, will be ready for dyeing purposes. Contact with air must, of course, be as far as possible avoided.

When the dye-bath is exhausted it may serve for a fresh operation by adding indigo, a little caustic soda, and boiling it as above with a certain quantity of turnips.

On the iron wire trellis there will remain hardly 5 or 6 per cent. of the original quantity of turnips. This residue may be used in paper making.

The simplicity of this new process may easily be proved by introducing into a closed tube a small quantity of indigo mixed with a few drops of soda or caustic potash, adding a small piece of turnip, and boiling; the indigo will rapidly lose its color, and redissolve and return to its original color by exposure to the air.

As turnips are not everywhere cultivated, and during certain seasons are not to be procured fresh, the author has found that the active principles may be extracted by boiling the turnips with water, under

* *Bulletin de la Société Chimique*, February, page 153.

a pressure of two or three atmospheres. C. Leuchs & Co., of Nuremberg, now manufacture, on a considerable scale, an extract of turnips, 1 kilogramme of which will dissolve cold 4 kilogrammes of indigo.

Note on the Purification of Platinum. By Mr. E. SONSTADT.

From the London Chemical News, No. 330.

The tendency of platinum to alloy with other metals at a temperature far below its fusing point is sufficiently well known to every user of platinum crucibles. It is equally well known that iron, &c., which has been absorbed by platinum cannot be removed, except superficially, by the action of hydrochloric acid for instance, nor even by heating in acid sulphate of potassium. Stas, in his memoir on the atomic weight of silver, &c., states that he purified his platinum vessels from iron by causing them to come in contact, at a red heat, with the vapor of chloride of ammonium. The process had to be repeated as often as any yellow sublimate was formed. This process is less effectual, or less conveniently and speedily effectual, than the modification of it that I have to propose; because, if the vapor of the sal ammoniac is generated from the solid salt in the vessel to be purified, the heat absorbed in the vaporization of the salt tends to keep the vessel at a temperature below that at which volatile metallic chlorides are most readily formed. Instead of chloride of ammonium, I put dry double chloride of ammonium and magnesium in the platinum vessel intended for purification. The vessel is then heated to about the fusing point of cast iron for about an hour. I find a Gore's furnace convenient for this purpose. In this process, not only is chloride of ammonium vapor given off for a long while with the double salt, at a temperature much above that at which chloride of ammonium alone volatilizes, but when that salt is completely expelled, the chloride of magnesium remaining is perpetually being decomposed with evolution of free chlorine, and, frequently, the formation of a crystalline crust of periclase lining the crucible. Platinum thus purified is softer and whiter than ordinary commercial platinum. The method is not available solely for the removal of iron, but retrieves crucibles that have become dark colored and brittle from exposure to gas flame, as well as crucibles that have been attacked by silicates during fusion of these with carbonate of sodium. I cannot conclude this note without remarking on the extreme facility with which platinum becomes impure by heating in contact with matters containing only a very small proportion of substance capable of attacking the metal. Thus, a platinum crucible becomes sensibly impure after prolonged ignition at a high temperature, bedded in commercial magnesia. On the other hand, I have kept a platinum crucible at a constant weight to the tenth of a milligramme over a series of intense ignitions, when the precaution has been taken to bed it in chemically pure magnesia.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, May 16, 1866.

The meeting was called to order with the President, William Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Board of Managers presented their minutes and reported, that, at their meeting on the 9th instant, they received donations to the library from the Royal Astronomical Society and the Society of Arts, London; l'Ecole des Mines, Paris, et la Société Industrielle de Mülhouse, France; der Oesterreichischen Ingenieur-vereins, und der Neideroesterreichischen Gewerbe-vereins, Wien, Austria; Isaac Newton, Esq., Commissioner of Agriculture, Frederick Emmerick, Esq., and George Metlar, Esq., Washington, D. C.; the Managers of the State Lunatic Asylum, Utica, and the Young Men's Association, Buffalo, New York; Edward F. Moody, Esq., Camden, New Jersey; and Henry Morris, Esq., Prof. John F. Frazer, the Guardians of the Poor, Dr. T. S. Kirkbride, and Robert S. Lewis, Esq., Philadelphia.

Three gentlemen were elected members of the Institute.

The various Standing Committees reported their minutes, and the Special Committee on Experiments in Steam Expansion reported progress.

The paper announced for the evening was then read by Mr. Emile Geyelin, on the Jonval Turbine, with special reference to the water-works lately constructed at Montreal. The abstract of this paper will appear in our next number.

The Report of the Resident Secretary on novelties in Science and the Mechanic Arts was then read, as follows:

SECRETARY'S REPORT.

Mechanics.—Improved Governor for Steam Engines, invented by David Shive of Philadelphia. In this instrument we have the following peculiarities of construction: The rods carrying the balls, in place of being so hung as to have a motion in a radial direction, as in the ordinary governor, are so arranged that their direction of motion is half way between a radial and tangential plane. This adjustment gives great delicacy or sensitiveness to any change in velocity, as is claimed, for the following reasons: Every change of velocity acts initially in a tangential direction upon the rods and balls. If, then, their only motion is in a radial direction, the first effect must be a binding or jamming at the guides and joints, succeeded by a radial motion, only as the resultant of the forward motion and this resistance. For this reason it might seem that a tangential motion would be the best to allow in the balls and arms, and such would be the case if the governor were normally at rest, and started back and forward when brought into action; but, being normally in motion, a resultant centrifugal tendency is developed, which would cause it to bind upon the

tangential guide or joint. These two difficulties are compromised, and the best result obtained, therefore, by an intermediate position of the plane of movement for the rods and balls. The nearly vertical direction, in which the balls hang, also adds to this same property of sensitiveness.

An Apparatus for the Preparation of Aromatic Infusions, invented by J. H. See of Charlestown, Mass., is constructed as follows: The lower portion, which may be detached from the rest by a single motion, is called the boiler, and consists of a closed cup or cylindrical vessel, having in its centre an open tube, running nearly to the bottom, around which several holes are pierced through the upper surface of the cup. These are covered by a loose rubber washer, which, however, is pressed firmly upon and closes them when the upper portion of the apparatus is attached in its place. This consists of a large vessel to receive the infusion when made, having a central tube, which, when in place, is continuous with that in the "boiler" already described. Upon the summit of this tube fits the central tube of a cup, with a finely perforated bottom, in which the substance to be treated, such as coffee, tea, &c., is placed. A lid to this cup, held down by friction and a spring within an outer lid, which covers all, acts as a safety valve to this apparatus. Water being placed in the boiler, and heated until it boils, the steam escapes under the loose washer; but when the upper part is secured in its place, this outlet is closed, and the steam, accumulating, forces the water to ascend the central pipe, to overflow into the cup, and, having percolated the matter there placed, to descend into the large receptacle. When the water has been thus driven out of the boiler, this may be separated from the rest of the apparatus. The water thus acting at a very high temperature, and under pressure, will remove most thoroughly all extractive matter from the substances treated.

The Rotary Steam Engine, invented by Matthew Fletcher, was described, as follows: A cylindrical drum, set eccentrically within a cylinder, is provided with four radial slots, in which work blades or flat-boards, which, as the drum revolves, are caused to move in and out.

Physics.—Freezing by Spray of Ether.—At a previous meeting the ingenious toy, called an "atomizer," by which perfumed liquids could be scattered through the air of an apartment, had been described and exhibited, when it was suggested that an action, capable of many useful applications in the future, was here represented. One of these applications, itself also but the forerunner of many more, was now before us, in the apparatus for production of intense cold and anæsthesia, invented by Dr. Richardson of England. By very simple mechanism, a constant blast of air was driven into a double nozzle, through the inner tube of which a jet of ether was forced from a bottle by part of the same air, while a larger portion escaped around the ether jet, scattering it in fine spray, and evaporating it, so as to produce very intense cold. The bulb of a thermometer, introduced into this spray, showed a temperature several degrees below zero, and the water in a

small glass test-tube was frozen in less than a minute when similarly placed. (This action was experimentally demonstrated.)

An interesting table, showing the temperatures obtained by the use of various volatile liquids with this apparatus, will be found in the *Chemical News* for this year, page 196. Pure ether gives the lowest —6° F; bisulphide of carbon, next, 0° F.; then aqua ammoniæ, specific gravity 88, 12.2° F.; and then alcohol, absolute, 17.6° F.

Freezing Machines Incorrectly Described.—In most of the foreign journals we find accounts of two machines, said to have been exhibited, which are so full of the grossest mistakes and impossible statements, that their insertion without comment implies, on the part of the respective editors, a free use of the useful scissors, unchecked by the labor of perusal.

In the first place (see *Practical Mechanics' Journal, Mechanics' Magazine*, &c., for December last) we have a machine in which, it is stated, that amylic ether (oxide of amyl) prepared from the peculiar alcohol of the potatoe, by treatment with sulphuric acid, is *liquefied by a pressure of 5 to 7 atmospheres*. We here remind our readers that this amylic ether is a *liquid boiling at 348.8° F*. The description quoted then proceeds to state that, after *becoming gas and forming ice*, this substance goes into spirals, where it freezes the water, and, after being *vaporized*, is absorbed by sulphuric acid. It is clear, of course, to all, that if the process described has any existence, methylic (not amylic) ether must be employed; but if we make this correction, we then find another mistake, since this body is not prepared from potatoe, but from wood spirit, and we still have the lamentable confusion of a double vaporization and duplicated freezing.

Again, we hear, in the *Chemical News*, page 118, and the *Mechanics' Magazine*, page 165, that "Signor Toselli operates a freezing machine by heating salt water to 100°, in a strong iron vessel, and collecting the vapor in another." The choice as to where the freezing occurs seems to be left to the fancy of the reader, which we also will not attempt to limit; for one place seems about as likely, *or unlikely*, as another.

Clay Gas Retorts, it is argued by a correspondent of the *Mechanics' Magazine*, are not, in the long run, economical, as compared with iron ones; for though they cost less and last longer, yet, on account of their inferior conducting power, they cause a waste of fuel, which more than compensates these other advantages. It is proposed, in this connexion, to use clay retorts next the fire, but iron ones in the upper part of each setting.

Artificial Stone, made by Ransome's process, from silicate of soda, sand, and chalk, seems to have been manufactured on a large scale, and pretty extensively employed, according to a long editorial notice in the London *Mechanics' Magazine*. The concentrated solution of silicate of soda is mixed with the other ingredients, when the whole is packed into moulds, from which the blocks are removed to a tank where they are basted, to use a culinary illustration, with a saturated solution of chloride of calcium, and are then subjected to a shower

bath, for the removal of soluble salts. By omitting the chalk, an excellent filtering stone is obtained. The artificial stone has been employed in the works of the Metropolitan Railway, on the London, Dover, and Cheltenham extensions, and elsewhere.

The Spectrum Band Peculiar to Sodium may be demonstrated to a large audience, by the yellow light given off by a rod of soda glass, when introduced in the oxohydrogen jet. This fact, first observed and demonstrated (as he believes) by Prof. Morton, was shown to the members present, as follows: An ordinary gas-microscope box, containing a lime light, has, in its front, a narrow vertical opening or slit, $\frac{3}{10}$ -inch high by $\frac{1}{30}$ -inch wide, distant $1\frac{1}{2}$ inch from the lime light. A common, uncorrected lens, of 7 inches focus, is so placed in front of this, as to give an image of the opening upon the screen. The whole apparatus then being turned away from the screen, one or two bisulphide of carbon prisms are placed in the path of the ray, and a spectrum, which may be readily made 15 feet long, and very bright, is thrown upon the screen. The lime cylinder or plate, which is giving the light, being then withdrawn, and a common glass rod substituted, the spectrum disappears, with the exception of a sharply defined yellow band, such as is produced by sodium in the spectroscope. This property of glass is curious, and probably results from the fact that this body, even when intensely heated, gives but a feeble light, while, where the jet strikes it, particles of sodium are instantly vaporized, and so intensely ignited as to produce a large volume of their peculiar yellow light. This light is clearly derived from the glass rod, and not from its more distant envelope of yellow flame, for if the rod is lowered out of the range with the opening, all light disappears from the screen, even though the yellow flame still reaches far beyond the opening in the lantern.

The Absorbent Power of Sodium Vapor or Yellow Light was then demonstrated by replacing the lime in the lantern, and then introducing a small Bunsen burner, in which a globule of sodium was supported by a platinum spoon, between the light and opening. In a few seconds the sodium was vaporized, and a black band was seen to cross the brilliant spectrum in the place before occupied by the yellow line given by the glass. The absorptive power of hyponitric acid, and of ammonia solution of cochineal, was also demonstrated. The arrangement of apparatus used on this occasion is of special interest, because it renders possible the demonstration to large audiences of the interesting phenomena of spectrum analysis, the absorption bands, &c., with the easily manageable lime light in place of the expensive and troublesome electric apparatus otherwise demanded.

Chemistry.—A new Process for the Manufacture of Oxygen is announced by M. Archereau. The substance employed is sulphuric acid, but the details are not given.

Chromate of Lead is apt to change from its first clear yellow to an undesirable orange tint. This may be prevented by keeping it for some time in the dark. It is also less likely to occur when nitrate of lead is used in the preparation than when the acetate is employed.

A new Form of Phosphorus, occurring as metallic crystalline plates and microscopic rhombohedra, is formed by dissolving red phosphorus in melted lead, and allowing it to crystallize out, on cooling. (See *Chemical News*, page 133.)

The Decomposition of Common Salt by Steam at very high temperatures, has been suggested by some observations on the products of volcanic action; but in the *Mechanics' Magazine*, page 197, we find a full discussion of the many attempts which have been already made in this direction, and of their ill-success.

A Test for Carbolic Acid, by which its usual adulteration with oil of tar may be readily recognized, is furnished in the solubility of the former in 25 to 70 parts of water, or in 2 parts of caustic soda solution. Oil of tar is nearly insoluble in both.

The Intermittent River, Bourne, making its appearance every 6 or 8 years, was, on the 13th of March, flowing past Croydon, England, at the rate of 20,000,000 to 30,000,000 of gallons per day.

The Analysis of the Red Sea Water lately made by MM. Robinet and Lefort, shows its identity with ordinary ocean water, and difference from that of the Dead Sea, thus disproving the supposed connexion of these by any subterraneous communication.

At the conclusion of the Secretary's Report the meeting was, on motion, adjourned.

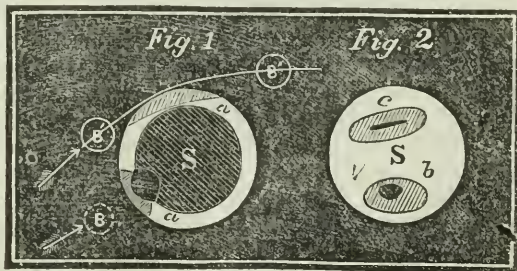
HENRY MORTON, *Secretary*.

The following abstract of remarks made at our last meeting was received too late for insertion in our previous number :

Origin of Spots on the Sun's Disk. By JOHN W. NYSTROM, C. E.

The spots seen upon the solar disk are, in my opinion, occasioned by large bodies falling into and making orifices in the sun's luminous envelope or photosphere, thereby forming the spots, which may be explained by the figures on the black-board, as follows :

Let Fig. 1 represent a section of the sun, of which the shaded part *s* is its supposed solid and opaque body, with its surrounding luminous atmosphere or photosphere *a a*. A body *B* striking in the direction of the arrow perpendicular to the surface would make an orifice in the luminous atmosphere appearing as a round spot *b*, Fig. 2; but when the body strikes the sun's crust it will probably be broken to pieces, and reacting thus upon the so-called photosphere, make the hole or spot more or less irregular.



It would be a rare chance that the body should arrive in a straight line towards the centre of the sun, but would generally move in a parabola, or some conic section, with the sun's centre as the focus, and parameter of its course may be such as to pass the body B' only through the luminous atmosphere, in which case the spot would appear oblong, as at c , Fig. 2. In most cases of bodies falling into the sun, the parameter of their course is such that the crust will be struck obliquely and the body burst to pieces, of which some fragments may glance off and fall back, and thus produce numerous other spots of various shapes and magnitudes.

Some striking bodies may be a great many thousands of miles in diameter, and make apertures which would require a time of many weeks or months to close up; regard being had to the peculiar constituency of the so-called sun's atmosphere.

Smaller bodies, which are probably very numerous and constantly falling into the sun, do not produce holes large enough to be visible through our present telescopes.

The appearance of the sides of the spots, or rather, the section of the luminous substance which envelops the body of the sun, leads us to suppose it to be a highly plastic or semi-fluid substance, which, by some physical action, is luminous only on its outer surface.

When a projectile strikes an armor-plate, the heat generated may be so intense as to actually melt some of the iron. When we know the weight and velocity of the projectile, or of the body striking the sun, we can calculate with great precision the quantity of heat generated in the collision.

The matter thus constantly flowing into the sun generates a great deal of heat in the collision besides that which is due to its own combustion. The sun is thus supported in its prodigal supplies of light and heat, which are the forms in which matter is returned throughout space, an operation which appears to be perpetual like that of rain and evaporation on the earth's surface.

There have been advanced two hypotheses regarding the physical constitution of light and heat, namely, the theory of *atomic emission* and the theory of *undulatory vibration*. The truth is, most probably, the combined result of both these theories, or that light and heat, &c., are imponderable matter propagated by undulatory vibrations, or, in other words, that a ray of light from the sun may be composed of all the elementary substances in nature, as indicated by the solar spectrum. The lines seen in spectrums of different lights not only represent certain substances but may be samples of the very atoms, and that each substance produces its own color and requires a specific grade of vibration for its propagation.

It appears that all matter is capable of being converted into four aggregate forms, namely, *solid*, *fluid*, *gaseous*, and *imponderable*. When it becomes *imponderable* it has, of course, no weight, because it is resolved into that very essence of matter, the action and reaction of whose atoms may constitute force or gravity.

The different forms of imponderable matter, such as *light*, *heat*, *ac-*

tinism, *electricity*, and *magnetism*, appear to be different compounds, which seem clearly to indicate their materiality, and that they possess inertia, of which the most striking illustration is the flow of electricity through Geissler's tubes.

The electric fluid flows through the irregularities of the tubes the same as a gas or a liquid would do; that is, its velocity through the narrow cylindrical parts of the tubes is continued by the inertia some distance into the globes. The bolt of lightning which tears asunder houses and trees, and ploughs up the ground, plainly indicates this to be the work of the inertia in the electric fluid.

The fact that a fine platina wire becomes red-hot when electricity passes through it from a thicker copper wire, proves that the imponderable fluid is squeezed into a narrower space with greater velocity than that which it passed through the copper wire. Such an operation cannot be explained simply by the undulatory law of vibration.

The very fact that light is refracted through a transparent body indicates light to be a material substance, and the fact that a ray of light is dispersed when passing through a prism to the spectrum, also indicates that it is composed of different substances, each of which takes its peculiar course of refraction.

The physical constitution of forces and of the undulatory vibration is yet a mystery to us. The undulatory vibration of the imponderable substances is evidently of two kinds and *in opposite directions*, constituting the forces of attraction and repulsion. The vibration of light emanating from the sun must evidently be opposite to the vibration forming the sun's attraction.

The intensity of light is analogous to temperature in heat, and can be converted into power or into the product of force, F , and velocity, v , whilst quantity of light is analogous to quantity or units of heat, which are convertible into physical work, or into the product of the three simple physical elements: force, F , velocity, v , and time, t .

It appears that $F v t$ is a trinity of physical elements which governs the material universe. All action of whatever kind, whether mechanical, chemical, or derived from light, heat, electricity, or magnetism; all that has been or is to be done or undone, is comprehended and expressed by the triune function $F v t$. It is omnipotent, ubiquitous, and eternal.

COMMITTEE ON SCIENCE AND THE ARTS.

Report on a System of Protection against Lightning for the Blockley Alms-house.

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred for examination the subject of a System of Protection against Lightning for the Blockley Alms-house,

REPORT: That the principal buildings of the Blockley Alms-house are erected around a square or court which contains within it the en-

gine and boiler house; the lengths of the buildings being, respectively, five hundred and twenty (520) feet on the south-east and north-west fronts, and three hundred and twenty (320) feet upon each of the other sides. Each front consists of a centre building connected by wings with end pavilions. The centre buildings of the north-east and south-west parts are ninety-four (94) feet in width and ninety-eight (98) feet deep, fifty-seven (57) feet in height from the ground to the top of the cornices and sixty-eight (68) feet to the combings of the roof; the tops of the chimnies, which are almost midway between the eaves and the combing, rising about two and a half ($2\frac{1}{2}$) feet above the level of the comb. The roof of this building is tin. The wings are one hundred and forty-seven (147) feet long by sixty-two (62) feet in depth, fifty-one (51) feet four (4) inches in height to the cornice, and the tops of the chimnies are nine (9) feet six (6) inches above the cornice. The roofs are gravel. The end pavilions are sixty-two (62) feet long by sixty-four (64) feet deep; the height of cornice and chimnies the same as on the wings. The roofs are of tin. On the north-east and south-west fronts the corresponding parts have the same heights and the roofs are of the same materials, (except that the roof of the eastern pavilion is of iron, which, in an electrical point of view, is an immaterial difference.) The centre buildings on these fronts are sixty-two (62) feet long by eighty-three (83) feet deep, the wings are one hundred and sixty-five (165) feet by seventy (70) feet, and the pavilions fifty-eight (58) feet by one hundred and twenty-six (126) feet.

Around the buildings, on the inner side, at a distance of seventeen (17) feet from the inner line of the south-east and north-west buildings and of forty-five (45) feet from the others, runs a line of four and a half ($4\frac{1}{2}$) inch cast iron pipe connected with the heating apparatus, and thus communicating with every part of the buildings and with the engine house.

The elements of efficient protection against lightning are, sufficient conductors, elevated enough above the highest points of the buildings to be protected, and close enough together to leave no portion unguarded, terminated above with sharp and durable metallic points to exercise their inductive action upon the clouds, and connected below with a sufficient surface of water or constantly moist ground to ensure easy electrical discharge. These conductors should all be connected together and have all large masses of metal in the building or its immediate vicinity connected with them by metallic communication.

To apply these principles to the building before us, we recommend that rods of one and a half ($1\frac{1}{2}$) inch round iron be erected on the chimnies of each front, (upon that side of the chimney which is towards the combing of the roof,) and that these rods be raised at least fifteen (15) feet above the tops of the chimnies, and, if necessary, properly staid by iron rods from the roof. (Experience has shown that a sufficient conductor is capable of protecting a circle around it whose radius is from two and a half ($2\frac{1}{2}$) to three (3) times the height of the point of the conductor above the plane to be protected. The chimnies on the centre building of the Alms-house are from six (6) to seven (7) feet

above the roof and about twenty (20) feet apart. On the other building they are four and a half ($4\frac{1}{2}$) feet in height and fifty (50) feet apart; from which it will be seen that rods raised fifteen (15) feet above the tops of the chimnies will cover with their protective influence the whole area of the roof.) At the level of the roof all these rods upon each building should be connected together by an iron rod of the same diameter, ($1\frac{1}{2}$ inches,) and this rod should, by soldering, be put into metallic connexion with each metallic roof over which it passes. At a convenient place on each building an iron rod of the same diameter should be connected with this and continued downwards to the ground and there put into metallic connexion with the pipes of the heating apparatus which surround the interior court. (Perhaps it would be better to have two such connecting rods for each building, one at each end.) The metallic pipes which are used to conduct the rain-water from the roof to the ground should also be put into metallic communication with the iron pipes of the heating apparatus. As an additional security, it would be expedient to connect the rods with the water and gas pipes of the house, the connexions to be made by soldering.

At their upper ends the lightning-rods erected upon the chimnies should be terminated by a brush or collar of points surrounding a central one. The points of the collar should be turned outwards at an angle of about forty-five (45) degrees, or, what would be better, the collar should be made with double the usual number of points, (say twenty (20),) and every alternate one turned out so as to be horizontal, the intermediate ones being bent outwards at an angle of forty-five (45) degrees. The committee recommend that the points should be of wrought iron and carefully and heavily gilded, so as to withstand all atmospheric influences, the length of the point being about six (6) times the diameter of the rod, or about nine (9) inches. If there be any difficulty found in having the iron permanently gilded, the points should be made of copper of the same dimensions and thoroughly gilded. The points ought to be, from time to time, examined, to see that they have retained their sharpness and that the gilding is intact.

With a system of rods thus provided, the work being well done, the Committee believe that the buildings will be entirely out of danger of any damage from lightning.

The centre buildings which contain the engine and boilers are already sufficiently protected by a rod erected upon the chimney.

JOHN F. FRAZER,
JOHN C. CRESSON,
FAIRMAN ROGERS,
Sub-Committee.

(By order of the Committee.)

WILLIAM HAMILTON,
Actuary.

Philadelphia, April 19, 1866.

A Comparison of some of the Meteorological Phenomena of APRIL, 1866, with those of APRIL, 1865, and of the same month for FIFTEEN years, at Philadelphia, Pa. Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½' N.; Longitude 75° 11¼' W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	April, 1866.	April, 1865.	April, for 15 years.
Thermometer—Highest—degree, .	82·00°	79·00°	88·00°
“ date, .	21st.	27th.	24th, '61.
Warmest day—mean,	73·17	68·83	74·83
“ “ date, .	21st.	27th.	29th, '56.
Lowest—degree, .	37·00	40·00	20·00
“ date, .	8th.	9th.	7th, '57.
Coldest day—mean,	38·67	45·50	27·70
“ “ date, .	8th.	9th.	2d, '57.
Mean daily oscillation,	14·17	14·33	16·31
“ “ range, .	6·09	5·99	6·21
Means at 7 A. M., .	50·30	51·25	46·16
“ “ 2 P. M., .	61·28	62·03	57·73
“ “ 9 P. M., .	54·80	54·48	49·94
“ for the month,	55·46	55·92	51·28
Barometer—Highest—inches, .	30·252 ins.	30·265 ins.	30·518 ins.
“ date, .	17th.	9th.	3d, '54.
Greatest mean daily press.	30·293	30·208	30·458
“ “ date, .	17th.	9th.	3d, '54.
Lowest—inches, .	28·820	29·404	28·820
“ date, .	23d.	1st.	23d, '66.
Least mean daily press.,	29·051	29·497	28·959
“ “ date, .	23d.	1st.	21st, '52.
Mean daily range, .	0·145	0·172	0·167
Means at 7 A. M., .	29·832	29·897	29·821
“ “ 2 P. M., .	29·771	29·844	29·778
“ “ 9 P. M., .	29·800	29·889	29·810
“ for the month, .	29·801	29·877	29·803
Force of Vapor—Greatest—inches, .	0·605 in.	0·689 in.	0·689 in.
“ date, .	21st.	29th.	29th, '65.
Least—inches, .	·094	·120	·066
“ date, .	9th.	24th.	13th, '52.
Means at 7 A. M., .	·266	·264	·234
“ “ 2 P. M., .	·302	·303	·251
“ “ 9 P. M., .	·305	·280	·254
“ for the month,	·292	·282	·246
Relative Humidity—Greatest—per ct.,	90·0 per ct.	93 per ct.	100 per ct.
“ date, .	19th.	12th.	often.
Least—per ct.,	18·0	23·0	13·0
“ date, .	29th.	24th.	13th, '52.
Means at 7 A. M.,	69·2	67·0	71·0
“ “ 2 P. M.,	51·9	52·6	51·4
“ “ 9 P. M.,	67·1	64·4	67·3
“ for the month	62·7	61·4	63·3
Clouds—Number of clear days,* .	7	9	8·4
“ “ cloudy days, .	23	21	21·6
Means of sky cov'd at 7 A. M.,	67·3 per ct.	61·3 per ct.	63·0 per ct.
“ “ “ 2 P. M.,	71·3	64·0	66·7
“ “ “ 9 P. M.,	54·3	51·0	53·5
“ “ “ for the month	64·3	58·8	61·0
Rain—Amount, .	2·922 ins.	2·829 ins.	4·687 ins.
No. of days on which rain fell, .	10	11	12·8
Prevailing Winds—Times in 1000,	N 74° 45' W 141	S 53° 8' W 179	N 66° 52' W 149

* Sky one-third or less covered at the hours of observation.

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ERRATA.

Page 319, equation over the table, for $x = \frac{w + \frac{3}{4}c}{wc}$ read $\frac{wc}{w + \frac{3}{4}c}$.

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